

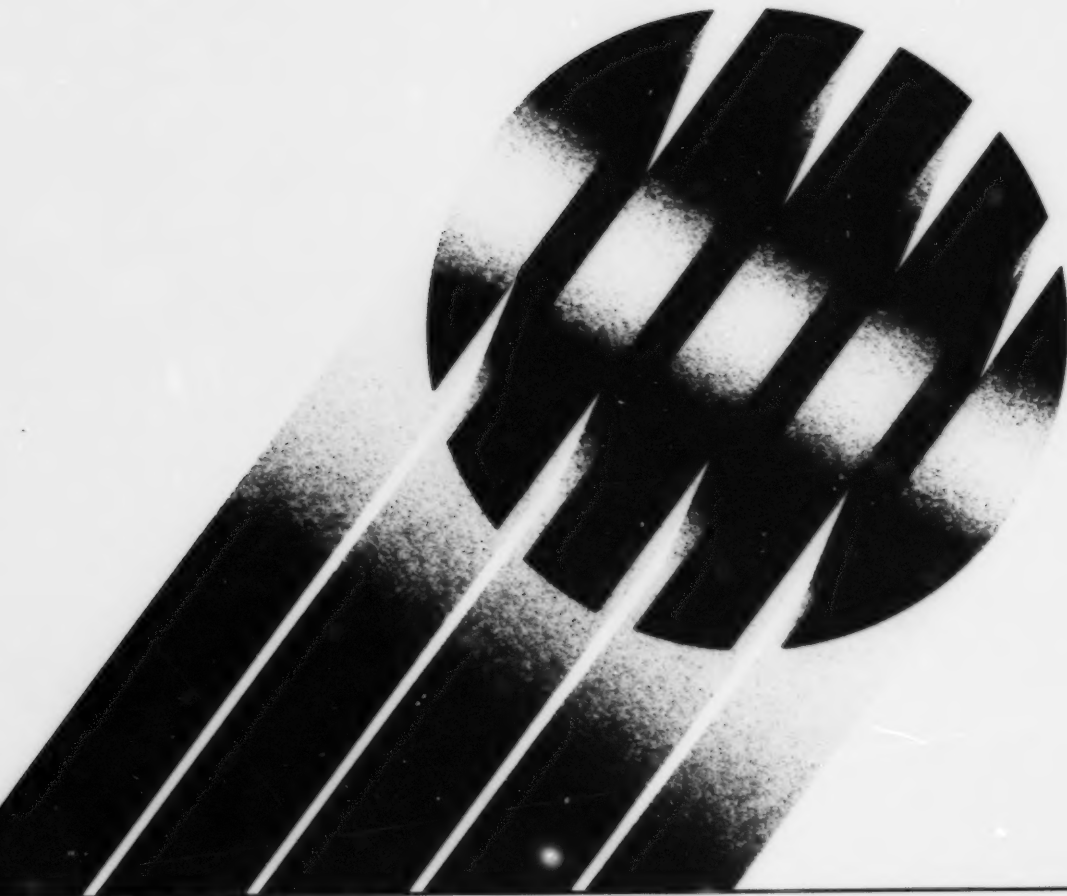
CANMET

Canada Centre for
Mineral and Energy
Technology

Centre canadien de la
technologie des
minéraux et de l'énergie

**SUMMARY REPORT NO. 9:
MAGNESITE, BRUCITE AND DOLOMITE**
R.K. COLLINGS AND P.R.A. ANDREWS
Mineral Processing Laboratory

MINERAL SCIENCES LABORATORIES



MSL 90-80 (R)



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R.K. Collings and P.R.A. Andrews
Mineral Processing Laboratory

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l'énergie (CANMET)

SUMMARY REPORT NO. 9: MAGNESITE, BRUCITE AND DOLOMITE

by

R.K. Collings* and P.R.A. Andrews****Abstract**

Magnesite, brucite and dolomite occur widely throughout Canada. Deposits of economic significance are, however, restricted to Quebec, Ontario and British Columbia. Magnesite is chiefly reported in Quebec, Ontario and British Columbia; brucite in Quebec and Ontario; and dolomite in Ontario.

The main end use for magnesite and, to a lesser extent, brucite, is the manufacture of refractory magnesia. The second largest use is the production of caustic-calcined magnesia which is used in a variety of industries and applications including agriculture, cement, pulp and paper, rubber, flame-retardant fillers, flue gas desulphurization and steelmaking.

The single largest consumer of dolomite is the aggregate and construction industry. The second largest use is the production of dolomitic lime for soil-acid neutralization in the agricultural industry. The refractory market for dolomite is much less than for magnesite, but dolime (dead-burnt dolomite) is used for refractory brick manufacture and in a variety of chemical and metallurgical applications. Dolomite is also used to reduce devitrification in glass and, as burnt dolomite, as a flux in steelmaking.

Magnesite, brucite and dolomite have been studied extensively at CANMET (between 1920 and 1974) using mineral processing and refractory evaluation techniques. Summaries of test reports are presented in the appendices under each mineral. Testwork summaries by other organizations are also included.

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RAPPORT SOMMAIRE N°9 : MAGNÉSITE, BRUCITE ET DOLOMIE

par

R.K. Collings* et P.R.A. Andrews****Résumé**

Partout au Canada, on trouve de la magnésite, de la brucite et de la dolomie. Les gisements de valeur économique se limitent toutefois au Québec, à l'Ontario et à la Colombie-Britannique. La magnésite est surtout présente au Québec, en Ontario et en Colombie-Britannique; la brucite au Québec et en Ontario; et la dolomie en Ontario.

La principale utilisation terminale de la magnésite et, dans une moindre mesure, de la brucite, est la fabrication de magnésie réfractaire. Sa deuxième utilisation en importance est la production de magnésie calcinée-caustique utilisée dans diverses industries et applications, notamment en agriculture, la fabrication du ciment, des pâtes et papier, de matières de charge ignifuges, la désulfurisation des gaz de combustion et l'élaboration de l'acier.

Le plus grand consommateur de dolomie est l'industrie des granulats et de la construction. Au deuxième rang, on trouve la production de chaux dolomitique servant à la neutralisation des sols acides dans l'industrie agricole. Le marché des produits réfractaires de la dolomie est moins important que celui de la magnésite, mais la dolomie frittée sert à fabriquer des briques réfractaires et a de nombreuses applications chimiques et métallurgiques. La dolomie sert également à réduire la dévitrification du verre et, comme la dolomie frittée, est utilisée comme fondant en sidérurgie.

La magnésite, la brucite et la dolomie ont fait l'objet de nombreuses études à CANMET (entre 1920 et 1974) dans le cadre desquelles on a eu recours à des techniques minéralurgiques et d'évaluation des propriétés réfractaires. Les résumés des rapports d'essai sont présentés dans les annexes de chacun de ces minéraux. Les résumés des travaux d'essai effectués par d'autres organismes sont également présentés.

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CONTENTS

	<u>Page</u>
ABSTRACT	i
RÉSUMÉ	ii
INTRODUCTION	1
MAGNESITE AND BRUCITE	1
Mineralogy and Geology	1
Principal Occurrences	2
Newfoundland	2
Nova Scotia	3
Quebec	3
Ontario	5
Manitoba	6
Saskatchewan	6
Alberta	7
British Columbia	7
Uses and Specifications	8
Refractory Magnesite	8
Caustic-calcined Magnesite	10
Fused Magnesite	11
Magnesium Metal	11
Magnesium Carbonate	12
Mining and Processing	12
Microcrystalline Magnesite	12
Macrocrystalline Magnesite	13
Synthetic or Sea Water Magnesite	13
Current Activity and Interest	14
Production, Trade and Consumption	16
Prices	16

CONTENTS (Cont'd)

	Page
DOLOMITE	20
Mineralogy and Geology	20
Principal Occurrences	20
Uses and Specifications	20
Aggregates and Construction Materials	22
Aggregates	22
Asphalt Filler	22
Cements	24
Agriculture	24
Neutralization	24
Other Uses	25
Chemical and Metallurgical	25
Dolime and Doloma	25
Magnesium Metal and Compounds	25
Steelmaking	26
Glass	27
Miscellaneous Uses	27
Mining and Processing	28
Current Activity and Interest	28
Production, Trade and Consumption	30
CANMET STUDIES	30
Background	30
Scale of Studies	33
Head Analyses	33
Mineralogy	39
Analysis Reporting	39
Beneficiation of Magnesite	40
Flotation	40
Alternative Beneficiation Methods	41

CONTENTS (Cont'd)

	<u>Page</u>
Refractory Evaluation	43
Beneficiation of Brucite	43
Flotation	43
Alternative Beneficiation Methods	44
Refractory Evaluation	44
Beneficiation of Dolomite	44
Alternative Beneficiation Methods	44
Refractory Evaluation	45
CONCLUDING COMMENT	45
ACKNOWLEDGEMENTS	45
GENERAL REFERENCES	46
MAGNESITE STUDY REFERENCES - CANMET	50
MAGNESITE STUDY REFERENCES - OTHERS	53
BRUCITE STUDY REFERENCES - CANMET	53
BRUCITE STUDY REFERENCES - OTHERS	54
DOLOMITE STUDY REFERENCES - CANMET	54

TABLES

<u>No.</u>		
1.	Magnesite, Hydromagnesite and Brucite Deposits in British Columbia	9
2.	Canadian Imports and Exports of Magnesite by Country of Origin and Destination for 1989-90	17
3.	Canadian Imports and Exports of Magnesite by Province for 1990	17
4.	Canadian Imports and Exports of Magnesia by Country of Origin and Destination for 1989-90	18

TABLES (Cont'd)

<u>No.</u>		<u>Page</u>
5.	Definitions and Specifications of Selected Crushed Dolomite Stone for Construction Uses	23
6.	Canadian Imports and Exports of Dolomite by Country of Origin and Destination for 1989-90	31
7.	Canadian Imports and Exports of Dolomite by Province for 1990	32
8.	Summary of Process Data for Magnesite Beneficiation Studies	34
9.	Summary of Analytical Data for Magnesite Beneficiation Studies	36
10.	Summary of Process Data for Brucite Beneficiation Studies	37
11.	Summary of Process Data for Dolomite Beneficiation Studies	38
12.	Summary of Flotation Data for Magnesite Rougher Flotation	42

FIGURES

1.	Principal Occurrences of Magnesite and Brucite	4
2.	Principal Occurrences of Dolomite	21

APPENDICES

1.	SUMMARIES OF CANMET MAGNESITE STUDIES	A-57
2.	SUMMARIES OF MAGNESITE STUDIES BY OTHER ORGANIZATIONS	B-83
3.	SUMMARIES OF CANMET BRUCITE STUDIES	C-89
4.	SUMMARIES OF BRUCITE STUDIES BY OTHER ORGANIZATIONS	D-95
5.	SUMMARIES OF CANMET DOLOMITE STUDIES	E-99

INTRODUCTION

A CANMET survey of Canadian industrial mineral producers (1) identified a number of problems specific to the industry as well as potential opportunities for further development and expansion. The response to this survey and subsequent discussions with industry and government specialists identified a requirement for information in a number of areas. These areas included mineral deposits, processing, beneficiation studies and new developments, as well as information on product specifications and potential markets for Canadian industrial minerals.

Related information on file at CANMET and, as available, from provincial government offices and the private sector were subsequently compiled in a series of Summary Reports on a number of industrial minerals. The information for each mineral pertains to mineral occurrences, deposits of specific interest, current activities, product uses and specifications, process technology, and summaries of past testwork on specific deposits by CANMET and others. This report, Summary No. 9: Magnesite, Brucite and Dolomite is the ninth in the series. The previous reports are:

No. 1	Barite
No. 2	Celestite
No. 3	Fluorite
No. 4	Silica
No. 5	Mica and Vermiculite
No. 6	Graphite
No. 7	Gypsum and Anhydrite
No. 8	Talc and Pyrophyllite

MAGNESITE AND BRUCITE (2,3)

Mineralogy and Geology

Magnesite (MgCO_3), when pure, contains 47.8% MgO and 52.2% CO_2 . Magnesite may be crystalline or amorphous (cryptocrystalline) and varies in colour from white to grey with

shades of yellow, blue and red. Hardness of the crystalline form ranges from 3.5 to 4.0 on the Mohs' scale. Deposits of crystalline magnesite are usually found associated with dolomite, the magnesite having been formed through the action of igneous intrusions and associated hydrothermal solutions on the dolomite. Additional associated minerals typically include talc, serpentine and olivine. Amorphous magnesite is an alteration product of serpentine or allied magnesium rocks, which have been subjected to the action of carbonate waters. Associated minerals usually include small amounts of limestone, iron oxides and silica.

Brucite ($\text{Mg}(\text{OH})_2$), when pure, contains 69.1% MgO and 20.9% H_2O . Brucite has a translucent appearance and is relatively soft and light in weight having a Mohs' hardness of only 2.5 and a specific gravity of 2.4. Brucite is usually white in colour but blue, green and grey varieties are common. Brucite is an alteration product of periclase, a relatively high-temperature magnesium mineral formed during the metamorphism of magnesium limestones or dolomites. Brucite occurs less commonly than magnesite and is usually associated with magnesite, limestone and dolomite.

Principal Occurrences

Magnesite and brucite occurrences have been recorded in Newfoundland, Nova Scotia, Quebec, Ontario, Manitoba, Saskatchewan and British Columbia. The more significant occurrences are in Quebec, Ontario and British Columbia. Occurrences of magnesite and brucite on a province-by-province basis are described below and recorded in the map, in Figure 1.

Newfoundland

Extensive talc-magnesite zones of possible economic interest have been identified in the Great Bend ultramafic and gabbroic rocks occurring in the east-central area of the province, 75 km southwest of Gander (4). Occurrences of magnesite are also recorded in the ultramafics of the Bay d'Espoir-Grand Falls region in the south-central region (5). Grady (6), who carried out a study of the ultramafics in this area, noted that magnesite was widespread in the Caribou Pond,

Coy Pond (Burnt Hill) and Great Bend areas. Kean (7) also noted the occurrence of large reserves of magnesite in the Great Bend ultramafic body, and suggested that the variable grade and high contents of iron oxide and silica made the deposits commercially unattractive. Soles (8) noted that rock samples from the Great Bend area contained 10 to 50% talc, 45 to 80% magnesite and 5 to 25% quartz, with accessory chromite, pyrite and magnetite. Soles further suggested that production of a refractory-grade concentrate would be difficult due to the fine grinding required to release dispersed talc, and to the presence of iron in the magnesite structure.

Nova Scotia

Magnesite occurs associated with zinc-cadmium deposits at Meat Cove in the most northerly part of Cape Breton Island. The host rock for the zinc-cadmium has been identified as a serpentine-brucite marble, reserves of which are estimated at 4.4 Mt grading 12% MgO (9). The Meat Cove zinc-cadmium deposits were the subject of intensive investigation during the period 1964 to 1972 (10). Magnesite has also been reported at Malagash in Cumberland County (11), and on the Point Road near Orangedale in Inverness County (12).

Quebec

Hébert and Paré (13) identified three magnesite-related mineral occurrences in Quebec, namely, the magnesitic-dolomite marble deposits of the Kilmar area; a massive carbonate zone containing 40 to 60% breunnerite (magnesite with iron carbonate) in the Johnson Asbestos Mine at Thetford Mines; and a magnesite deposit in the Otish Mountains area of New Quebec. Magnesite also occurs in Bolton, Sutton (14) and Montauban Townships (15).

Hébert and Paré also identified three brucite deposits, namely, the Wakefield area (Hull, Wakefield and Masham townships), where more than 20 deposits of brucitic marble occur; Carswell and associated deposits near Bryson in Pontiac County; and the La Trappe

LEGEND

NEWFOUNDLAND

1. Great Bend

NOVA SCOTIA

2. Meat Cove

QUEBEC

3. Thetford Mines
4. Kilmar
5. Wakefield
6. Carswell / Bryson / Calumet Island
7. La Trappe
8. Otish Mountains

ONTARIO

9. Rutherglen
10. Deloro Township

MANITOBA

11. Iskwasum Lake

SASKATCHEWAN

12. Mosher Lake

BRITISH COLUMBIA

13. Radium Hot Springs (including Mount Brussilof and Mount Eon)
14. Kamloops Area
15. West Redonda Island
16. Tlupana Arm, Kennedy Lake
17. Atlin

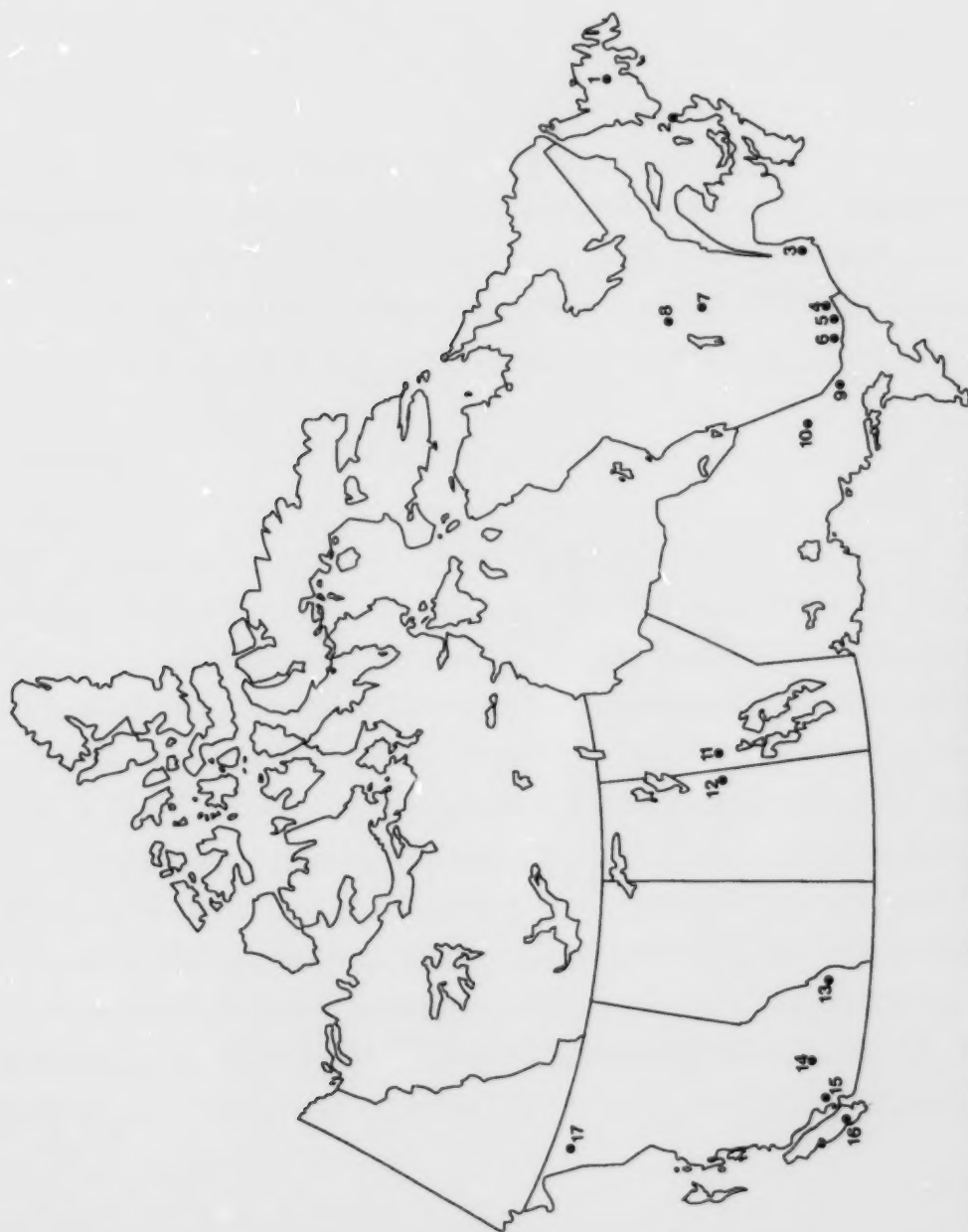


Figure 1. PRINCIPAL OCCURENCES OF MAGNESITE AND BRUCITE

occurrence north of Lake St. John. The Wakefield and Bryson area deposits, as well as minor deposits on Calumet Island, are described in detail by Goudge (16). Brucite also occurs at the Martin-Bennet chrome pit in Ireland Township, Megantic County (17).

Ontario

Two interesting magnesite/talc deposits occur in the Timmins area of northern Ontario: the magnesite/talc deposit in Deloro Township, 15 km south of Timmins, and the Allerston talc/magnesite deposit in Whitney Township, 15 km east of Timmins (18). These ultramafic-hosted deposits were extensively investigated in the mid 60s and early 70s for the recovery of bulk magnesite and talc.

The Deloro deposit has proven reserves of 20 Mt, and drill-indicated reserves to a depth of 250 m are estimated at 90 Mt. The mineralogical composition of the deposit is 54% magnesite, 28% talc, 16% quartz and 3% accessory iron oxide minerals. The deposit is also characterized by low CaO and relatively high Fe_2O_3 values. Bench-scale testwork conducted by Lakefield Research in 1963, and pilot plant testwork conducted in 1964 at North Bay, Ontario, indicated that high-grade magnesite and talc concentrates could be obtained. The Lakefield Research testwork indicated that the iron oxide content could only be reduced to 6% Fe_2O_3 (19), but the pilot plant testwork at North Bay indicated that a magnesite concentrate analyzing 99.1% acid soluble (46% MgO), 2.85% Fe_2O_3 and 0.5% SiO_2 could be obtained. The iron oxide was mainly present as ferrous oxide in the magnesite mineral lattice and cannot be removed by physical methods of separation. The magnesite concentrate was subsequently calcined, ground and briquetted. Dead-burning studies conducted by Canadian Refractories Limited and CANMET confirmed that a high density refractory magnesia could be produced. The reduction of the lattice-held iron by chemical methods was studied but proved to be uneconomic. The by-product talc was high grade, but was considered to be too abrasive for most uses due to the presence of quartz.

The Allerston talc magnesite deposit was investigated by Rosaric Resources Canada Limited by stripping, drilling and bulk sampling. Results indicated several orebodies containing an estimated 36.8 Mt grading 42% magnesite, 41% talc, and 6 to 12% chlorite. Metallurgical studies indicated the technical feasibility of producing a high-purity talc concentrate suitable for use by the paper industry.

Goudge (16) identified a number of occurrences of brucitic limestone in the Rutherglen area, midway between Mattawa and North Bay. Four are described in some detail, namely, Pimisi Bay, Mattawa River-Lake Talon, McDonough and Crooked Lake. The brucite occurs as white to grey granules, 1 to 4 mm in diameter, in a white limestone-dolomite matrix. Chemical analyses of selected samples showed brucite contents varying between 24 and 34%. Brucite also occurs in Olvig, Calvin (20,21) and Hinchinbrook Townships (22).

Breunnerite occurs in Rothburn Township on the east shore of Wanapitei Lake, Scadding Township (23).

Manitoba

Magnesite intermixed with talc occurs in association with quartz, dolomite and iron oxides at Ikwassum Lake in the Flin Flon-Snow Lake area of northern Manitoba. Samples analyzed by X-ray diffraction contained from 1 to 43% magnesite; three contained 12, 34 and 43% magnesite, respectively. A more detailed summary of this occurrence and other occurrences will be included in a final Canada-Manitoba Mineral Development Agreement report by Gunter (24).

Saskatchewan

Magnesite has been reported as occurring on the west side of Mosher Lake in northeastern Saskatchewan. Drill programs carried out in 1954 and 1966 showed intersections of

magnesite (17 m) and talcy magnesite (32 m) at depth; however, little additional information is available on this occurrence (25).

Alberta

Deposits of magnesite are not recorded in Alberta; however, the Cambrian Cathedral Formation, the host formation for the extensive magnesite deposits of southeastern British Columbia, outcrops extensively in southwestern Alberta, principally in National Parks. An area immediately adjacent to the parks could be of potential interest in future exploration for magnesite (26).

British Columbia

Magnesite occurs in the southeastern area of British Columbia near Radium Hot Springs on the western flank of Mount Brussilof, and to the north of Mount Eon between the Mitchell and Assinibone Rivers. The Mount Brussilof occurrence is believed to be the largest and purest coarsely crystalline magnesite deposit in the western world. This deposit is now being mined and consistently produces a magnesia product grading 97% MgO or better using only simple beneficiation techniques (27). Current published reserves of several grades of magnesite are as follows:

95% MgO or more	- 9.5 Mt
93 to 95% MgO	- 13.6 Mt
92 to 93% MgO	- 17.6 Mt

Grant (28) identified thirty-nine magnesite, five brucite and nineteen hydro-magnesite deposits in British Columbia. The magnesite deposits are divided into a number of categories, i.e., carbonate-hosted, quartzite-hosted, ultramafic alteration, ultramafic-lateritic and other. The carbonate-hosted, quartzite-hosted, and other deposits mostly occur in the southeastern area of the province. The ultramafic-alteration deposits are evenly divided between the south-central and the far northwestern areas of the province. The hydro-

magnesite deposits are in the south-central part with one exception, i.e., Atlin, which is in the far northwest. Two of the brucite deposits are on Vancouver Island, a third is on the mainland in the southwest, and the remaining two are in the northwest near the Yukon border. These occurrences are listed under the noted sub-divisions in Table 1.

Uses and Specifications (2,3)

The principal use of magnesite and, to a lesser degree, brucite is in the manufacture of basic refractory products such as bricks and ramming mixes for lining or grouting cement kilns, and for lining glass, steel, and copper furnaces and retorts.

Magnesite dissociates on heating to form magnesia and carbon dioxide; brucite dissociates on heating to form magnesia and water. A crystal structure similar to that of the mineral periclase develops on further heating magnesia to 1450°C. The resulting material is commonly termed dead-burned magnesia or refractory magnesia. A lighter, more absorbent product, caustic-calcined magnesia, may be produced by firing at temperatures below 900°C.

A more detailed description of pyrometallurgical and ceramic properties of magnesite in Canada is given by Palfreyman (29). A similar detailed description is also available for brucite (30).

Refractory Magnesia (31)

The most important consumer of magnesite-based refractories is the iron and steel industry, although the fastest growing sector is the cement industry. The most important use of magnesite refractories is in lining pneumatic oxygen steelmaking vessels, on which the bulk of steelmaking capacity is now based. Magnesite refractories are also used in the

Table 1. Magnesite, Hydromagnesite and Brucite Deposits in British Columbia (28)

CARBONATE-HOSTED MAGNESITE

- M1 Mount Brussilof (Baymag)
- M2 Red Mountain
- M3 Topaz Lake
- M4 Cleland Lake
- M5 Jab
- M6 Botts Lake
- M7 Dunbar Creek
- M8 Chuyazega Creek
- M9 Lac la Hache
- M10 O'Donnel
- M39 Chischa

QUARTZITE-HOSTED MAGNESITE

- M11 Marysville
- M12 Driftwood Creek
- M13 Princess
- M14 Mallandaine Pass
- M15 Fort Steele
- M16 Wallinger
- M17 Boulder Creek

**ULTRAMAFIC-ALTERATION
MAGNESITE**

- M18 Liza Lake A
- M19 Liza Lake B
- M20 Yalakom River
- M21 Noaxe Creek
- M22 Mission Mountain
- M23 Ferguson
- M24 Pinchi Lake
- M25 Anzac
- M26 Ruby Mountain
- M27 Pike
- M28 McKee Creek
- M29 Yellow Jacket
- M30 Anaconda
- M31 Sloko River
- M32 Graham Inlet
- M33 Peninsula Mountain
- M38 St. Joseph's Mission

ULTRAMAFIC-LATERITIC MAGNESITE

- M34 Bonaparte River

OTHER MAGNESITE

- M35 Sinclair Mills
- M36 Illecillewaet
- M37 Invermere

HYDROMAGNESITE

- H1 Atlin
- H2 Clinton
- H3 Watson Lake
- H4 Sixtyone Creek
- H5 Riske Creek
- H6 Meadow Lake
- H7 Taseko River
- H8 Big Creek
- H9 Gay Lake
- H10 Fletcher Lake
- H11 Springhouse
- H12 Barnes Lake
- H13 Basque 1
- H14 Campbell Range
- H15 Buse Lake
- H16 Barnhart Vale
- H17 Alexis Creek - Lot 561
- H18 Alexis Lake - Lot 2833
- H19 141 Mile House

BRUCITE

- B1 Atlin Road
- B2 Hurricane Creek
- B3 West Redonda Island
- B4 Tlupana Arm
- B5 Kennedy Lake

linings of electric arc and open hearth furnaces, and in ladle linings. The quality of magnesite used in these applications varies considerably. The stringent operating conditions of oxygen converters require a lining that must withstand higher temperatures, rapid changes in temperatures, and more severe mechanical loads than experienced in other furnaces. Refractory-grade magnesia is usually over 96% MgO, has a specific gravity of at least 3.2, is low in iron oxide, and contains no free lime. Free lime can hydrate on exposure to moisture and causes the product, whether brick or flooring, to swell and spall.

Caustic-calcined Magnesia (32)

The major growth areas for caustic-calcined magnesia are in the agriculture sector where magnesia is used in animal feedstuffs, particularly for dairy cattle, and in fertilizers, mainly for root crops. Magnesium deficiency is generally associated with sandy soils. Major industrial applications of caustic magnesia include the following:

1. **Cement** - for the production of magnesium oxychloride and oxysulphate, which are used as a resilient flooring in industrial buildings.
2. **Pulp and paper** - where magnesia is used for the preparation of magnesium sulphite lye used in the "magnefite" papermaking process.
3. **Rubber** - magnesia is particularly effective in controlling vulcanization and curing in neoprene rubbers and other elastomers.
4. **Plastics, paints, adhesives** - a flame retardant filler.
5. **Abrasives** - as a binder in grinding wheels.
6. **Lubricating oils** - as an additive to neutralize acids.
7. **Boiler fuels** - as an additive to reduce the emission of sulphur and other pollutants.
8. **Flue gas desulphurization** - removal of sulphur dioxide.
9. **Flux in steelmaking** - normally used when magnesia is more readily available than dolime or olivine.

10. **Chemicals** - when magnesia is a starting point for the production of other magnesium salts such as sulphate, nitrate, etc.
11. **Pharmaceuticals** - special grades of oxide, hydroxide, and carbonate are used in antacids, cosmetics, toothpaste, ointments, milk of magnesia, etc.
12. **Steel coatings** - to coat grain-orientated silicon steel used in electrical transformer cores.
13. **Fused magnesia** - caustic magnesia as a raw material for fused magnesia production.

Specifications for caustic magnesia vary with use and application, but they are generally similar to refractory-grade magnesia.

Fused Magnesia (32)

The traditional use of fused magnesia is in electrical insulation applications such as sheathed heating elements for domestic appliances, and in industrial heating applications. Insulation usage requires a naturally high quality MgO (>95% MgO), with lime:silica ratios often favouring silica.

The other main use of fused magnesia, in refractories, is the rapidly expanding use as mag-carbon refractories based on fused magnesia and graphite being used increasingly for hot spots of basic oxygen steelmaking furnaces. Fused magnesia for this purpose tends to be denser than insulation grade (S.G. >3.50), and lime:silica ratios should be 2:1 or greater.

Magnesium Metal

An important application for high-grade magnesite is in the production of magnesium metal. The magnesite is first converted to magnesium chloride brine by leaching with hydrochloric acid. The magnesium chloride brine is then dehydrated to form magnesium chloride prills, which subsequently are reduced to magnesium metal in electrolytic cells.

Magnesium Carbonate

Magnesium carbonate has some usage in film coatings for highlighting, whereby the intagliations (indented lettering) on a coloured, film-coated tablet are highlighted in white (33).

Mining and Processing

Magnesite and brucite ores are mined by open-pit methods when deposits are large and at or near the surface. Deposits occurring at depth are mined by conventional stoping methods. Processing essentially consists of crushing and sizing followed, as required, by heavy media separation, and possibly by further grinding and flotation.

A brucite deposit near Wakefield, Quebec, in which the brucite occurs as small 2 to 3 mm grains in a limestone matrix, was treated by crushing and calcination followed by slaking. The discharge from the slaker, consisting of hydrated lime dust and magnesia granules, was passed through an air separator to separate and recover both the magnesia and lime (16).

Magnesite for refractory use is calcined prior to being formed into the desired block or brick shapes. Magnesite and brucite ores can be classified as microcrystalline, macrocrystalline, and sea water or synthetic magnesia.

Microcrystalline Magnesite (34)

Microcrystalline magnesite deposits are limited in size. They are relatively shallow and have a very low ore to waste ratio, rendering them expensive to operate, and consequently few can be worked economically. Where operated, however, the microcrystalline deposits can be efficiently beneficiated. They are usually low in iron and free from boron. The impurities are not continuous throughout the magnesia and, on sintering, are isolated into pockets. The ore can be readily sintered into a high-density product with low pore volume. The sintered

magnesia meets the requirements for high MgO, low boron, low iron, high density, and large average diameter periclase crystals with good crystal bonds.

Macrocrystalline Magnesite (34)

The large crystalline magnesite deposits, both the high-iron and low-iron varieties, are the most economical to exploit. These usually can be mined by open pit methods, the deposits continuing to fairly extensive depths. The disadvantages of such deposits are associated with the size of the crystals, tendency of crystals to decrepitate, and distribution of impurities. The iron is quite often in solid solution and cannot be removed except chemically; lime and dolomite particles are often present, and the sintered magnesite often contains pore spaces. Furthermore, the magnesite ore cannot produce a high-density product without special treatment, and the chemistry of the final product cannot be easily controlled. In general, these deposits do not make a high-purity refractory product.

Synthetic or Sea Water Magnesia (34)

Synthetic magnesia produced from sea water has the advantage of high purity and can be adjusted to customer requirements. There is little or no limitation on the magnesia reserves as this only depends on the alkali precipitants, which are usually large orebodies of lime or dolomite, and fresh water for washing purposes. The magnesia can be sintered to a high density, and the average crystal diameter of the magnesia is usually in the range of 40 to 80 μm .

Magnesia produced by this method has a higher boron content than magnesite ore, and requires special processing to decrease the boron content. The iron content is low and the lime:silica ratio can be easily adjusted. The energy requirements are relatively high compared with those of a natural magnesite. The energy requirements for both the alkali precipitant and filter cake have been reduced through improved methods of calcining by the use of a pressurized shaft kiln, which requires only 40% of the energy of the rotary kiln for

dead burning. Improved dewatering of the slurry by pressure filtration further reduces energy requirements.

Current Activity and Interest

A number of companies in Canada have interest in magnesite for use in refractory products and in the production of magnesium metal. There are, however, only two producers, one of magnesite in British Columbia, the other of magnesite-dolomite in Quebec. There is also current interest in utilizing high-magnesite asbestos tailings from the Thetford Mines, Quebec, area for magnesium metal production. Magnesium metal is currently produced in Quebec using high-grade magnesite imported from China.

Canadian Refractories Limited, mines an underground magnesite-dolomite deposit near Kilmar, Quebec, for use in basic refractories. The ore body consists of a series of veins that dip 85°. The mined ore is crushed to about 40 mm and washed and sized at about 5 mm. The coarse, plus 5 mm, fraction is treated by heavy media separation to recover magnesite which reports in the "sinks", the "floats" being discarded. The coarse magnesite concentrates are blended with minus 5 mm, high-grade magnesite fines, and the combined ore ground in a ball mill. The ground ore is briquetted and calcined in a rotary kiln at 1500 to 1800°C to produce a dead-burned magnesia product. This product is recrushed and shipped to a company-owned refractory brick plant at Marelán, 15 km south of Kilmar, and to customers in the United States.

Norsk Hydro A/S of Norway has constructed a new magnesium plant which is soon to go on-stream (35). The plant, located in Becancour, Quebec, is expected to have a capacity of 50,000 tpa of magnesium metal, and will use its own proprietary process utilizing high-grade magnesite from China. The magnesite is leached with hydrochloric acid to produce magnesium chloride prills. The prills are subsequently reduced in electrolytic cells to magnesium metal. The company initially had planned to use dolomite from the

Harve St. Pierre area in northeastern Quebec to produce MgO, but chose instead the less costly chloride route using imported, high-purity magnesite.

Noranda Mines Limited and Lavalin Incorporated have formed a joint venture company, Magnola, to investigate the production of magnesium metal from high-magnesite asbestos tailings in the Thetford Mines, Quebec, district. The technical and economic feasibility of this venture are to be determined during a planned 24-month study.

A new primary magnesium metal plant at Alderside near High River, Alberta, which was completed by Magnesium Company of Canada Limited (Magcan), at the end of 1989 (35), is expected to close in 1991 following a decision not to continue funding the additional start-up costs associated with the project. Low magnesium prices, high operating costs and lower-than-anticipated production are some of the reasons cited. The major raw material used in magnesium production was magnesite from Baymag's high-grade deposit near Radium Hot Springs, British Columbia. Magcan is a joint venture between the Alberta Natural Gas Company and Magnesium International Corporation Limited. Magnesium International was formed by Mineral Processing Licensing Corporation (MPLC) of the United Kingdom in order to generate the commercialization of an entirely new magnesium production process it had developed in the United Kingdom. The new technology produces molten magnesium chloride for subsequent electrolytic reduction to high-purity magnesium metal. The major advantage of MPLC's proprietary process is the unique single-step carbo-chlorination of magnesite ore which produces anhydrous magnesium chloride salt for feed to electrolytic cells. MPLC claims that the capital, energy, and labour savings gained through this process yield significant competitive advantages over other magnesium production routes. The plant was only operating at 50% of the projected production capacity of 12,500 tpa magnesium metal.

Magnesium Refractories Limited, recently acquired the talc-magnesite deposit at Deloro, Ontario, near Timmins, from Pamour Mines Incorporated. The deposit was originally investigated in the 1960s by Canadian Magnesite Mines to produce marketable-grade MgO.

The presence of 6% Fe_2O_3 in the dead-burned MgO product discouraged any further development. A pre-feasibility report (36) prepared for Magnesium Refractories Limited, indicated that the deposit may be successfully developed to produce a commercial-grade refractory MgO product and, after chemical treatment using the Ruthner process, a high-grade MgO product. A preliminary market study concluded that the initial process plant should be designed to process 360,000 tpa of ore to produce 50,000 tpa of commercial grade dead-burned MgO, 12,500 tpa of caustic-calcined MgO, 30,000 tpa of high purity MgO (Ruthner Process), and 80,000 tpa of talc.

Baymag Mines Company Limited, quarries high-quality magnesite from a deposit located on the north side of Mount Eon, about 65 km northeast of Radium Hot Springs in southeastern British Columbia. The ore is crushed, sized, and shipped to a company plant near Exshaw, Alberta, where it is converted to MgO and fused magnesia. In April 1988 (37) the company announced plans to expand the magnesium oxide facility. The present capacity of the calcining plant is 60,000 tpa and the planned investment will increase this figure by some 20% to bring the total capacity to 72,000 tpa.

Production, Trade and Consumption

Imports of magnesite into, and exports from, Canada are reported in Table 2. The data is further divided, in Table 3, to indicate which provinces imported and exported magnesite. Import and export data for magnesia is reported in Table 4.

Prices

The prices for magnesite products per tonne are variable: calcined agricultural grade sells for U.S. \$145-160; calcined (natural) for U.S. \$225-490; calcined (sea water) for U.S. \$300-600; and dead-burned brickmaking grade U.S. \$270-450.

Table 2. Canadian Imports and Exports of Magnesite* by Country of Origin and Destination for 1989-90

	1989		1990	
	Quantity tonnes	Value \$000s	Quantity tonnes	Value \$000s
Imports				
Natural magnesite in crude rock form	96,729	5,792	96,340	4,250
China	210	46	103	27
United States	96,939	5,838	96,443	4,277
TOTAL				
Natural magnesite in other forms (processed)				
United States	332	163	272	142
Austria	105	51	-	-
TOTAL	437	214	272	142
Exports				
Natural magnesite (all forms)				
United States	402	332	52	10
Japan	72	49	-	-
Columbia	20	67	-	-
TOTAL	494	448	52	10

Table 3. Canadian Imports and Exports of Magnesite* by Province for 1990

	1990	
	Quantity tonnes	Value \$000s
Imports		
Natural magnesium carbonate (crude rock form)		
Quebec	96,340	4,250
Ontario	103	27
TOTAL	96,443	4,277
Natural magnesium carbonate (other)		
Quebec	53	23
Ontario	200	109
Alberta	15	8
British Columbia	4	2
TOTAL	272	142
Exports		
Natural magnesium carbonate (all forms)		
Quebec	10	4
Alberta	42	6
TOTAL	52	10

Source: Statistics Canada, International Trade Division

* Includes brucite

**Table 4. Canadian Imports and Exports of Magnesia* by
Country of Origin and Destination for 1989-90**

	1989		1990	
	Quantity tonnes	Value \$000s	Quantity tonnes	Value \$000s
Imports				
Magnesia, fused, dead-burned etc. and magnesium oxide pure or not less than 94% pure				
Dead-Burned (sintered)				
United States	51,706	16,741	52,224	17,292
France	-	-	3	2
Germany, West	570	256	314	131
Greece	100	44	-	-
Netherlands	200	100	-	-
China	8,883	922	6,410	827
Japan	24	19	1	1
TOTAL	61,483	18,082	58,952	18,253
Fused				
United States	-	-	199	303
TOTAL	-	-	199	303
Caustic Burned				
United States	-	-	65	33
China	-	-	476	87
TOTAL	-	-	541	120
Abrasive Grains				
United States	31	28	33	28
Germany, West	-	-	0.7	-
Italy	0.10	-	-	-
TOTAL	31.1	28	33.7	28
Other (n.s.)				
United States	2,727	2,466	25,255	10,131
United Kingdom	399	153	215	136
Germany, West	-	-	8	33
Netherlands	57	30	-	-
Japan	238	969	367	1,331
TOTAL	3,421	3,618	25,845	11,631
Dead Burned				
United States	2,868	1,022	3,468	1,407
Austria	-	-	1,500	649
Germany, West	1,500	540	-	-
South Africa	2,955	1,793	2,000	1,307
China	12,155	1,194	635	467
TOTAL	19,478	4,549	7,603	3,830

Table 4. (Cont'd)

	1989		1990	
	Quantity tonnes	Value \$000s	Quantity tonnes	Value \$000s
Imports (Cont'd)				
Caustic Burned (n.s.)				
United States	-	-	44	24
TOTAL	-	-	44	24
Other (n.s.)				
United States	1,821	740	1,414	688
Italy	15	8	196	86
Norway	-	-	5,000	54
Japan	5	2	-	-
TOTAL	1,841	750	6,610	828
Exports				
Magnesia, fused, dead-burned etc., and magnesium oxide pure or not less than 94% pure				
United States	51,386	14,488	53,002	15,766
United Kingdom	86	15	-	-
Austria	1,161	849	1723	1,292
Denmark	-	-	20	14
Germany, West	2,218	1,805	4,288	3,741
Italy	220	176	574	466
Spain	320	256	160	128
Sweden	54	17	114	40
Switzerland	40	32	-	-
Germany, East	40	32	-	-
South Africa	101	81	381	275
India	18	14	-	-
Korea, South	17	77	-	-
Philippines	40	30	-	-
Australia	150	107	90	53
Argentina	10	11	35	29
Brazil	300	252	600	324
Chile	54	68	54	68
Colombia	18	8	18	10
Venezuela	101	52	20	22
TOTAL	56,334	18,370	61,079	22,228

Source: Statistics Canada, International Trade Division

* Includes brucite

n.s. not specified

DOLOMITE

Mineralogy and Geology

Dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$), in pure form, contains 54.3% CaCO_3 (calcite) and 45.7% MgCO_3 (magnesite). Dolomite may be white, pink, green or gray in colour. Dolomite has a hardness of 3.5 to 4.0 on the Mohs' scale and a specific gravity of 2.8. Although some dolomites undoubtedly have been formed by direct precipitation from sea water, most varieties have resulted from the alteration of calcium carbonate sediments by hypersaline brines. Common associated impurities include clay, chert and silica (38).

Principal Occurrences

Dolomite and dolomitic-limestone deposits are widespread in Canada and too numerous to detail in this report. Deposits operated for non-stone or aggregate purposes are noted later in the Current Activity and Interest section. A number of the more important deposits are noted on the map in Figure 2. Readers requiring more detailed information on such deposits are referred to a number of excellent provincial government publications: e.g., Newfoundland (39), Nova Scotia and New Brunswick (40-42), Quebec (43,44), Ontario (45-48), Manitoba, Saskatchewan, Alberta and British Columbia (49-54).

Uses and Specifications

Dolomite is widely used for its physical properties such as colour, sheen, strength and durability. The end uses can be divided into the following four categories:

Aggregates and construction materials

Agricultural

Chemical and metallurgical

Miscellaneous

LEGEND

NEWFOUNDLAND

1. Cape Norman
2. Port au Choix, Deer Cove
3. Goose Arm
4. Port-au-Port Peninsula
5. Labrador City

NOVA SCOTIA

6. North Ingonish, Cape Dauphin, Kelly Cove
7. Churchview, Kewstake, Glencoe, Glendale, Stony Creek
8. Musquodoboit Valley

NEW BRUNSWICK

9. Lorneville, Brookville
10. Armstrong Brook

QUEBEC

11. Phillipsburg, Cowanville
12. Huntingdon, Landreville
13. Portage-du-Fort
14. Harve St. Pierre
15. Fermeont

ONTARIO

16. Rockland
17. Portland
18. Madoc
19. Bancroft
20. Haley
21. Lake Nipissing
- 22-23. Niagara Falls - Hamilton
- 23-24. Hamilton - Guelph
- 24-25. Guelph - Alton
- 25-26. Alton - Durham
- 26-27. Durham - Owen Sound
- 27-28. Owen Sound - Tobermory
29. Manitoulin Island
30. New Liskeard
31. Albany River
32. Thunder Bay

MANITOBA

33. Winnipeg
34. Fairford
35. Grand Rapids
36. The Pas
37. Wekusko, Comorant

SASKATCHEWAN

38. Deschambault Lake, Hanson Lake, Amisk Lake

ALBERTA

39. Nordegg
40. Banff, Gap Lake, Sawbuck
41. Crownest

BRITISH COLUMBIA

42. Fairmont, Spillimacheen
43. Glenogle, Yoho Valley



Figure 2. PRINCIPAL OCCURENCES OF DOLOMITE

Aggregates and Construction Materials (55)

Aggregates

Crushed dolomite is used in Portland cement concrete for roads, buildings and other structures; in combination with bituminous materials for roads and similar construction; and as decorative stone for landscaping and in terrazzo applications.

The aggregate and construction market is the single largest consumer of dolomite, but exact figures are difficult to obtain since most producers process limestone and dolomite, and do not differentiate between the two minerals. An indication of the wide range of aggregate applications is shown in Table 5.

In addition to particle size distribution, the main specifications for aggregates relate to wear resistance, soundness, deleterious substances, shape, porosity and chemical compatibility. Potentially deleterious substances include chert, shale and clay. The maximum allowable limit of clay lumps for Portland cement concrete is 1% in fine aggregate, and 0.25% in coarse aggregate. Soft and unsound fragments in coarse aggregates, including chert, should not exceed 5%. In general, concrete aggregate should be low in alkalis and free from surface inorganic matter; the presence of opaline silica is highly undesirable. In aggregates for bituminous road surfacing, allowable maxima for clay lumps is 0.5 to 1.0% according to the type of construction, and for shale from 2.0 to 4.0%.

Asphalt Filler (55)

Asphalt filler is a finely ground dolomite, 80% passing 75 μm with the oversize only slightly above 75 μm . The specifications for mineral filler in sheet asphalt and bituminous concrete pavement require 100% passing 60 μm , with at least 65% passing 75 μm .

Table 5. Definitions and Specifications of Selected Crushed Dolomite Stone for Construction Uses (56)

Type	Description and Specification
Macadam	Nominal gradation from 90 to 25 mm
Riptrap and jetty stone	Heavy irregular rock chunks used for river, dam, harbour, shore and embankment protection
Filter stone	Crushed stone used as sublayer under graded riprap or jetty stone
Concrete aggregate (coarse)	Nominal gradation from 90 to 5 mm
Bituminous aggregate (coarse)	Nominal gradation from 90 to 5 mm
Bituminous surface treatment aggregate	Nominal gradation from 38 mm
Railroad ballast	Nominal gradation from 38 to 19 mm
Stone sand-concrete	Crushed fine aggregate produced from quarried stone, nominal gradation from 5 mm to 75 μ m
Stone sand-bituminous mix or seal	Crushed fine aggregate produced from quarried stone, nominal gradation from 5 mm to 75 μ m
Graded roadbase or sub-base	Nominal gradation from 50 mm to 75 μ m
Unpaved road surfacing	Nominal gradation from 25 mm to 75 μ m

Cements (55)

The use of dolomite is limited in common cement applications. Specifications for Portland cement require a content of greater than 75% CaCO_3 and less than 3% MgCO_3 , which tends to favour limestone. Dolomite has been used in the manufacture of natural cement, e.g., when material containing 13 to 35% clay (of which silica is 10 to 22%) and 4 to 16% alumina and iron oxide are used. Natural cement is intermediate between Portland cement and hydraulic lime, but differs from the latter in that lumps do not slake in water. Semi-calcined dolomite can be employed in the manufacture of magnesium oxychloride and oxysulphate cements. The oxychloride cement is used as a thickener in the manufacture of polyester sheet moulding materials, when it forms a salt with the carboxylic end groups of the polyester molecules. Desirable properties of oxychloride cement include its resistance to solvents, good compressive and flexural strength, comparatively low cost, and fire and vermin-proof characteristics.

Agriculture (55)

Neutralization

The agricultural sector is dolomite's second largest market. Aglime is produced by crushing and grinding calcitic or dolomitic limestone for soil acidity neutralization; the size range is usually 24 mm to 150 μm . Other benefits of aglime are enhancement of calcium and magnesium soil content, improved soil structure, and maintaining or promoting conditions favourable for the utilization of soil nutrients by plants, and for the growth of desirable soil organisms.

Aglime purity is measured by its calcium carbonate equivalent (CCE). The CCE is a measure of the pure calcium and magnesium carbonate present in the limestone, and is defined as an expression of the acid-neutralizing capacity of a carbonate rock relative to that of pure dolomite (CCE equal to 108.5%).

Other Uses (55)

In fertilizers, dolomite may be used as filter material to add weight, reduce caking, improve the physical condition of the mixture, and to adjust the blend to the desired ratios of fertilizing elements. Dolomite also neutralizes the physiological acidity of the fertilizer. Dolomite is used as poultry grit and mineral food, although high-calcium limestone is preferred.

Chemical and Metallurgical (55)

Dolime and Doloma

Dolime or dolomitic lime refers to the burnt product of dolomite or dolomitic limestone. Dolime may contain 18.0 to 45.0% MgO, and 30.0 to 57.5% CaO depending on the raw material burnt; it can also be referred to as low- or high-magnesium lime.

Doloma, another form of burnt dolomite, is formed from sintering or dead burning dolomite at elevated temperatures. It is much denser and more inert than dolime. The actual sintering temperature varies according to the purity of the dolomite. High-purity, low-iron dolomite for refractory brickmaking requires a temperature of about 1800°C, whereas lower purity dolomite for fettling purposes (to which iron oxide is often added) is generally sintered in the 1400 to 1600°C range.

Dolime and doloma are both used in a variety of chemical and metallurgical applications.

Magnesium Metal and Compounds (55)

Dolomite is one of the primary raw materials for the manufacture of magnesium metal and some magnesium compounds. Magnesium metal is produced by two processes: electrolytic and pyrometallurgical. The electrolytic route, which involves the electrolysis of molten

magnesium chloride using seawater brines, was developed by three companies: Dow, IG Farben and Norsk Hydro A/S. The pyrometallurgical route, which involves the thermal reduction of magnesium oxide using magnesium minerals, is referred to as the Pidgeon, Italian or Magnetherm process.

The two most important magnesium compounds are magnesia, MgO , and magnesium hydroxide, $\text{Mg}(\text{OH})_2$. The primary end-use of magnesia is as a refractory material. Magnesium hydroxide is marketed as a source of magnesia and as a neutralization agent.

Steelmaking (55)

Dolime is used as a flux in steelmaking where it reacts with silica, alumina, sulphur and phosphorus impurities in the melt to form a slag, which is then separated from the metal. Specifications for dolime flux vary with the steelmaking process, variety of ore processed, and the final use of the slag. Silica content should not exceed 2 to 5%, magnesia can vary from less than 4 up to 15%, and sulphur should be less than 0.1%. Size specifications also vary, but are generally in the range of 25 to 100 mm, 50 to 100 mm, and 75 to 150 mm.

Doloma is used both in the manufacture of refractory bricks and shapes, and for monolithic refractories. The presence of lime in doloma can lead to extreme reactivity with water. It is necessary, therefore, either to coat doloma bricks with tar or pitch or to convert the free lime to a calcium silicate or ferrite by the addition of iron oxide or a siliceous material prior to dead burning the original dolomite.

The main applications for doloma bricks are in basic oxygen furnaces, ladle linings, argon oxygen decarbonization vessels, cement kilns and, to some extent, electric arc furnaces. Grades of doloma for brickmaking are generally chemically purer than those used for fettling, with many approaching pure dolomite and containing only small amounts of impurities such as iron oxide (0.7 to 1.0%), alumina (0.8 to 1.0%) and silica (1.3 to 1.5%).

Glass (55)

Dolomite in the glass batch reduces the tendency for devitrification, inhibits chemical attack by atmospheric gases or moisture, and improves workability through lowering the settling rate. In coloured glasses, dolomite smoothes out viscosity differences at varying temperatures, increases thermal shock fracture resistance, and contributes additional fluxing action. Dolomite for the glass industry is usually in the form of crushed stone, with chemical and size specifications dependent on the type of glass being produced; iron oxide contents in dolomite should be very low, between 0.002 and 0.005 %.

Miscellaneous Uses (55)

Dolomite is used for a variety of minor applications. These include filler applications in adhesives and sealants, paper, plastics, paints, putty, rubber, plasters, carpet-foam detergents, foods and cosmetics. Dolomite for these applications is finely ground to precise size specifications and, in some instances, may be treated chemically to enhance certain properties.

White dolomite fillers in paint improve colour, weatherability and mechanical stability, and reduce shrinkage, internal stress, fissure development, and water and oil-absorption. Dolomite fillers also provide very cost-effective substitutes for more expensive titanium dioxide in white and pastel paint formulations.

Dolomite rock can be used as a sewage filter bed if it is durable, highly porous, and possesses an irregular surface to trap bacteria. Siliceous impurities are not objectionable if fine grained and evenly distributed, although clay and pyrite are undesirable.

Other uses for dolomite include its use in mineral wool manufacture, in flue gas desulphurization, as dimension stone and stone chips, and as coal mine dust to prevent and retard coal dust explosions.

Mining and Processing

Dolomite is mined by open pit methods, although underground mining of high-grade deposits for specific applications may sometimes be undertaken. Building and dimension stone production require particular care in stone reduction and sawing or otherwise removing blocks from the quarry, for later cutting and dressing to required shapes and dimensions. Stone for use as construction or decorative aggregate, and for use in chemical (as opposed to physical) applications, is obtained by standard quarrying methods, the rock being crushed, sized and ground to required specifications. Heavy media separation and flotation may occasionally be used to produce higher quality products for special use or application.

Current Activity and Interest

Dolomite for use as dimension stone and in aggregate applications is produced at many locations in Canada. Operations for non-stone or aggregate applications are relatively few, however, and essentially restricted to magnesium metal manufacture, for fluxing purposes, and as a mineral filler. A number of non-stone/aggregate operations are described as follows.

The Iron Ore Company of Canada obtains dolomite from a dolomitic marble deposit near Labrador City, for use in the production of self-fluxing "dolomitic type" iron ore pellets at its Labrador City iron ore facility. The dolomite is ground to 70% minus 75 μm and mixed with the iron ore in the ratio of 1:9 prior to pelletizing. Dolomitic content is about 7%, as the dolomite 'ore' contains only about 70% dolomite, the remainder being calcium carbonate.

In Nova Scotia, there are several deposits of limestone and dolomite. Scotia Limestone Limited, owns a dolomite quarry at Kelly Cove on Cape Breton Island, which contains an estimated 3.2 Mt of limestone and dolomite. The deposit is operated by Mosher Limestone, which recently installed a grinding mill and constructed a loading dock for shipment of dolomite to Prince Edward Island and Quebec (57). The largest and best quality carbonate

deposit in Nova Scotia, with excellent potential for development, is located at Glencoe, Inverness County. The Glencoe deposit contains an estimated 310 Mt of cement-grade limestone, 210 Mt of metallurgical limestone, and 4.5 Mt of dolomite. Another dolomite deposit, at Churchview in the same Glencoe location, has an estimated 3.9 Mt of dolomite (55).

Timminco Limited produces magnesium metal by the Pidgeon process from dolomite at Haley, near Renfrew, Ontario. The dolomite obtained from a nearby quarry is crushed, blended with finely divided ferrosilicon, and fired in vacuum retort furnaces where the magnesium crystallizes as 'crowns' which are recovered, crushed and refined. The input capacity of 60,000 t of calcined dolomite and ferrosilicon yields 11,000 t of magnesium metal and alloys per year (58).

Canada Talc Limited mines talc-associated dolomite from an underground deposit at Madoc, Ontario. Following crushing, grinding and sizing operations, the dolomite is marketed as terrazzo and decorative chips. A filler-grade product, Talfil, is also marketed. Talfil is used in carpet backing, in insecticides, and for various other applications.

Steetley Quarry Products Incorporated produces dead-burned dolomite and dolime at its plant at Dundas, Ontario. These products are used mainly by the metallurgical and glass industries.

Dolowhite Mines Limited produces dolomite chips and agricultural dolomite from a deposit at Rock Creek in the Okanagan Valley, British Columbia (59).

Amasco Limited mines dolomite at Crawford Bay, Creston, British Columbia, and grinds dolomite at Sindar, on Kootenay Lake, for agricultural purposes (59).

A large dolomite and limestone deposit occurs at Sechelt, British Columbia, where reserves are estimated at 110 Mt of dolomite and 24 Mt of limestone. Exploratory work was

undertaken at Candol Developments Limited in early 1986, but no further developments have been reported (60).

Production, Trade and Consumption

Imports of dolomite into, and exports from, Canada are reported in Table 6. The data is further divided, in Table 7, to indicate which provinces imported and exported dolomite.

CANMET STUDIES

Background

Twenty-three CANMET magnesite studies (61-83), four brucite studies (10,88-90), and nine dolomite evaluation studies (93-101), were reviewed. Several studies were conducted by other organizations including four on magnesite (84-87) and two on brucite (91-92). Summaries of CANMET magnesite studies are reported in Appendix 1, and by other organizations in Appendix 2. Summaries of CANMET brucite studies are reported in Appendix 3, and by other organizations in Appendix 4. The CANMET dolomite studies are summarized in Appendix 5.

The summary of each study includes, if known, the original sample weight, head analysis, mineralogy, beneficiation methods, beneficiation product sizes, concentrate grades and recoveries, and remarks or observations of particular interest. The original sample weight is indicative of the scale of investigation, whether bench, laboratory, semi-pilot plant or pilot plant. The head analyses provide data concerning the mineral content and whether the sample originates from a high- or low-grade deposit. Mineralogical information not only identifies major and minor minerals, but also provides data regarding association between minerals and host rocks. The liberation size in many cases is either not known or not stated; the beneficiation product size is quoted since, by inference, product size under optimum test conditions usually equates to liberation size. Beneficiation methods are important as a guide

Table 6. Canadian Imports and Exports of Dolomite by Country of Origin and Destination for 1989-90

	1989		1990	
	Quantity tonnes	Value \$000s	Quantity tonnes	Value \$000s
Imports				
Dolomite not calcined				
United States	10,272	54	1,630	364
United Kingdom	62	11	12	3
TOTAL	10,334	65	1,642	367
Calcined dolomite				
United States	6,614	573	3,022	332
TOTAL	6,614	573	3,022	332
Agglomerated dolomite (including tarred dolomite)				
United States	42	21	57	30
TOTAL	42	21	57	30
Exports				
Dolomite not calcined				
United States	459,914	4,159	858,327	4,208
TOTAL	459,914	4,159	858,327	4,208
Calcined dolomite				
United States	24,881	3,591	38,074	4,615
United Kingdom	-	-	175	40
TOTAL	24,881	3,591	38,249	4,655
Agglomerated dolomite (including tarred dolomite)				
United States	915	88	149	11
TOTAL	915	88	149	11

Source: Statistics Canada, International Trade Division

Table 7. Canadian Imports and Exports of Dolomite by Province for 1990

	1990	
	Quantity tonnes	Value \$000s
<u>Imports</u>		
Dolomite not calcined		
Nova Scotia	565	121
New Brunswick	21	4
Quebec	2.7	n.r.
Ontario	1,050	239
Alberta	0.6	n.r.
British Columbia	3.3	1
TOTAL	1642.6	365
Calcined dolomite		
Nova Scotia	158	34
New Brunswick	15	1
Quebec	60	7
Ontario	2,156	231
Manitoba	42	5
Alberta	592	51
TOTAL	3,023	329
Agglomerated dolomite (including tarred dolomite)		
Quebec	55	29
Ontario	2	1
TOTAL	57	30
<u>Exports</u>		
Dolomite not calcined		
Ontario	858,327	4,208
TOTAL	858,327	4,208
Calcined dolomite		
Ontario	38,249	4,655
TOTAL	38,249	4,655
Agglomerated dolomite (including tarred dolomite)		
Ontario	149	11
TOTAL	149	11

Source: Statistics Canada, International Trade Division
n.r. not reported

for future studies of ores with similar mineral assemblages, and concentrate grade and recovery figures provide an indication of how efficient the beneficiation methods were in achieving a specification product. Additional data regarding flotation parameter and reagent concentration were also reported. Studies common to a particular deposit, where possible, are grouped together for continuity and convenience of reference.

The magnesite, brucite and dolomite studies were conducted by CANMET and its predecessor, Mines Branch, between 1920 and 1974. The majority were on samples from Quebec, Ontario and British Columbia, although samples from Newfoundland, Nova Scotia, New Brunswick and Manitoba were also evaluated.

A summary of process data for magnesite beneficiation studies is reported in Table 8, and a summary of analytical data in Table 9. A summary of process data for brucite beneficiation studies is reported in Table 10, and a similar summary for dolomite in Table 11.

Scale of Studies

The feed weight varied from 3 kg (77) to 2,000 t (86,87) in fact, five studies were conducted on samples weighing 3 t or more (65,73,81,86,87). The feed weight for brucite beneficiation studies was between 2.5 kg (10) and 270 kg (88), and for dolomite between 6 kg (94) and 450 kg (93).

Head Analyses

The analyses of magnesite samples varied from 38% magnesite for an ore from Timmins, Ontario, (75) to 91.4% magnesite for an ore from Cranbrook, British Columbia (80). The analyses for most ores, however, were greater than 50% magnesite. The analyses of brucite samples, with one exception (90), were all less than 19%. Dolomite samples, conversely, were mostly all high grade.

Table 8. Summary of Process Data for Magnesite Beneficiation Studies

Deposit Location	Lot. No.	Sample Wt (kg)	Product Size	Process Methods	Reference No.
Newfoundland	n.s.	1	n.s.	grinding, desliming, flotation, regrinding, refloatation	61
	n.s.	1	n.s.	sizing, heavy media separation	83
Quebec				grinding, sizing, magnetic separation, flotation	
				grinding, sizing, heavy media separation	
	Kilmar	1	n.s.	air tabling	62
		2	n.s.	sizing, wet tabling, air tabling	
	Kilmar	1	27.0 t	crushing, grinding, hydrosizing, desliming, flotation, regrinding, refloatation	63
		2	38.3 t		
		3	30.0 t		
	Kilmar	1	91	sizing, heavy media separation	64
	Kilmar	1	8 t	crushing, sizing, heavy media separation	65
		2	8 t	crushing, sizing, heavy media separation	
	Kilmar	1	110*	crushing, grinding, desliming, flotation	66
		2	110*	crushing, grinding, desliming, flotation	
		3	110*	crushing, grinding, desliming, flotation	
		4	110*	crushing, grinding, desliming, flotation	
		5	110*	crushing, grinding, desliming, flotation	
Kilmar	1	365	-300 μ m	dewatering, rake classification, filtration	67
Kilmar	1	n.s.	+25 mm, +19 mm, +13 mm, +10 mm, +6.7 mm, -6.7 mm	sizing, photometric sorting	68
Grenville	1	n.s.	n.s.	calcination, slaking, classification, washing	69
Grenville	1	n.s.	n.s.	calcination, slaking, classification, washing	70
	2	n.s.	n.s.	calcination, slaking, classification, washing	
	3	n.s.	n.s.	calcination, slaking, classification, washing	

Table 8. (Cont'd)

Deposit Location	Lot. No.	Sample Wt (kg)	Product Size	Process Methods	Reference No.
Ontario	Grenville	1	n.s.	vibration grinding	71
	Deloro	1	80% -22 μ m, 63% -11 μ m	crushing, grinding, flotation, refloatation, magnetic separation	72
	Deloro	1	750	crushing, autogenous grinding, flotation, regrinding, refloatation, magnetic separation	73
	Timmins	1	4 t	crushing, grinding, flotation, regrinding, refloatation, magnetic separation	75
	Timmins	1	100	grinding, compaction, calcination, firing	76
	Deloro	1	n.s.	crushing, grinding, flotation, magnetic separation	85
	Timmins	1	500	grinding, flotation, calcination, hydration, high-pressure briquetting, dead-burning	86
	Deloro	1	2000 t	crushing, grinding, flotation, gravity concentration	87
	Deloro	1	2000 t	crushing, desliming, flotation, magnetic separation	77
	Cranberry	1	3	crushing, grinding, flotation	79
British Columbia	Cranbrook	1	n.s.	crushing, grinding, flotation, firing evaluation	80
	Cranbrook	1	n.s.	crushing, grinding, flotation, calcination	81
	Fort Steele	1	3 t	crushing, grinding, flotation, calcination	82
		2	3 t	calcination, grinding, pressing, drying, firing	83
	n.s.	1	4.5	calcination, grinding, drying, pressing, firing	
	Brussilof	1	n.s.		

n.s. - not specified

* estimated

Table 9. Summary of Analytical Data for Magnesite Beneficiation Studies

Deposit Location	Lot No.	Head Analysis %			Product Analysis %			Recovery %	Reference No.
		MgCO ₃	Insol	Fe ₂ O ₃	MgCO ₃	Insol	Fe ₂ O ₃		
Newfoundland									
n.s.	1	n.s.	n.s.	-	80.2	10.6	-	33.3	61
n.s.	1	n.s.	n.s.	n.s.	79.4	2.9	n.s.	n.s.	84
Quebec									
Kilmar	1	80.0	n.s.	-	90.0	n.s.	-	n.s.	62
	2	65.0	n.s.	-	90.0	n.s.	-	n.s.	
Kilmar	1	51.0	10.0	-	n.s.	n.s.	-	55.0	63
	2	57.0	6.0	-	n.s.	n.s.	-	55.0	
	3	46.0	9.0	-	n.s.	n.s.	-	55.0	
Kilmar	1	35.0	n.s.	-	51.0	n.s.	-	53.5	64
Kilmar	1	n.s.	n.s.	-	n.s.	3.0	-	40.0	65
	2	n.s.	n.s.	-	n.s.	3.0	-	60.0	
Kilmar	1	84.2	3.1	0.68	90.7	0.05	n.s.	77.0	66
	2	92.2	10.3	1.20	84.2	1.26	n.s.	47.8	
	3	60.1	1.3	0.52	86.1	0.55	n.s.	45.2	
	4	90.1	2.9	0.34	98.9	0.24	n.s.	100.0*	
	5	80.2	0.8	0.36	96.0	-	n.s.	76.5	
Kilmar	1	65.7	11.1	-	n.s.	n.s.	-	80.0	67
Ontario									
Deloro	1	57.0	38.0	n.s.	99.4	n.s.	2.94	63.4	72
Deloro	1	57.0	38.0	n.s.	99.2	0.56	2.96	n.s.	73
Timmins	1	38.0	50.0	12.0	99.1	n.s.	6.37	n.s.	75
Timmins	1	63.0	n.s.	6.3	93.0 ¹	1.00	6.00	n.s.	85
	2	52.3	n.s.	5.7	93.0 ¹	1.00	6.00	n.s.	
Deloro	1	54.0	44.0	n.s.	99.1	0.50	2.85	70.0	86
Deloro	1	n.s.	n.s.	n.s.	96.0	0.42	n.s.	71.5	87
Manitoba									
Cranberry	1	52.0	43.0	5.0	85.9	n.s.	4.38	86.1	77
British Columbia									
Cranbrook	1	n.s.	n.s.	-	92.8	n.s.	-	91.1	79
Cranbrook	1	91.4	8.9	-	96.1	n.s.	-	86.4	80
Fort Steele	1	87.0	12.0	1.0	95.0	n.s.	n.s.	90.0	81
	2	47.0	51.0	2.0	92.0	n.s.	n.s.	80.0	

¹ MgO

n.s. - not specified * calculated

Table 10. Summary of Process Data for Brucite Beneficiation Studies

Deposit Location	Lot. No.	Sample Wt (kg)	Product Size	Process Methods	Reference No.
Nova Scotia					
Meat Cove	1	2.5	-200 +6.5 mm	screening, calcination, hydration, drying, washing, scrubbing, screening	10
Quebec					
Wakefield	1	270	-20 +12.5 mm, -12.5 +9.5 mm, -9.5 +4.8 mm	screening, absorption, sulphate soundness loss, concrete aggregate evaluation	88
Wakefield	1	65	-12.5 +9.5 mm, -9.5 +4.8 mm	screening, photometric sorting	89
Bryson	1	n.s.	n.s.	washing, flotation	91
Ontario					
Farm Point	1	n.s.	-300 +60 μ m	crushing, grinding, desliming, flotation	90
Rutherglen	1	125	n.s.	crushing, grinding, flotation	92

n.s. - not specified

Table 11. Summary of Process Data for Dolomite Beneficiation Studies

Deposit Location	Lot. No.	Sample Wt (kg)	Product Size	Process Methods	Reference No.
Nova Scotia	1	450	-19 mm	crushing, screening	93
New Brunswick	1	6	-44 μ m	calcination, cooling, pulverizing, slaking	94
	2	6	-44 μ m	calcination, cooling, pulverizing, slaking	
	3	6	-44 μ m	calcination, cooling, pulverizing, slaking	
Quebec	1	15	-12.5 + 4.8 mm -300 μ m	crushing, screening crushing, grinding, flotation, calcination	95
Ontario	5	n.s.	n.s.	calcination, slaking	96
	1	n.s.	-44 μ m	calcination, cooling, pulverizing, slaking	97
	1	90	-100 μ m	screening	98
	1	430	-75 μ m	air classification	99
	1	n.s.	-12.5 + 9.5 mm, -9.5 + 4.8 mm	screening, photometric sorting	100
	1	n.s.	n.s.	calcination, fettling evaluation, dolomite stabilization	101

n.s. - not specified

Mineralogy

The various magnesite samples were associated with either dolomite, serpentine and brucite, or talc, quartz, chlorite, hematite and iron oxide minerals. A similar suite of minerals occurred with brucite; namely, calcite, magnesite, dolomite, serpentine, iron oxide and iron sulphide minerals. In one study, graphite was present (88). The minerals associated with the low-grade dolomite samples were calcite, limestone and quartz.

Analysis Reporting

Magnesite, brucite and dolomite are basically simple chemical compounds, either magnesium carbonate (magnesite), magnesium hydroxide (brucite), or mixed magnesium and calcium carbonates (dolomite). Magnesite and brucite analyses are usually reported as per cent MgO. A rapid and reasonably accurate analysis method for magnesite is per cent CO₂. Conversion to magnesite is possible by multiplying by 1.91. Dolomite analyses are usually reported as per cent LOI.

The presence of various silicate minerals complicates the analysis procedure and can introduce inaccuracies. The presence of talc in magnesite ores, for example, alters the MgO content, so that it may be necessary to use acid insoluble to determine the magnesite content. The LOI method is similarly restricted if chlorite is present, since chlorite disintegrates at temperatures generally employed for LOI determinations.

An accurate method of analysis is differential thermal analysis, which is based on differing temperatures for loss on ignition of minerals usually associated with magnesite ores. Chlorite conversion occurs at 570°C, magnesite at 660°C, calcite at 800°C, and talc at 970°C. Dolomite conversion is probably between magnesite and calcite.

Beneficiation of Magnesite

The evaluation of magnesite ores involved a two-stage processing route. Magnesite ores were first beneficiated by mineral processing techniques to produce a magnesite concentrate, and then subsequently calcined for refractory use evaluation. Processing to yield magnesite concentrates involved grinding, flotation, heavy media separation, wet and dry gravity concentration, photometric sorting and magnetic separation. Each processing method depended on a different criteria for separation.

Flotation

Flotation of magnesite involved either direct flotation of magnesite from other minerals (61,63,66,79,80,81), or the removal of talc, quartz and other silicate minerals leaving a beneficiated magnesite product (72,73,75,77). Flotation was conducted on fine-ground ore, which was generally less than 210 μm . The coarsest grind size was 400 μm (63). Magnesite is a semi-soluble salt mineral, so that flotation collectors for magnesite are generally the fatty acid type. Various derivatives were employed including Neo Fat 142 (61,80), Harfat (81), and oleic acid (63,66,79). The collector concentrations were: Neo Fat 142 (650 to 920 g/t), Harfat 920 g/t and oleic acid (100 to 900 g/t). These high levels of collector are to be expected, since the presence of dissolved Ca^{2+} and Mg^{2+} will precipitate fatty acid type collectors.

The modifiers and depressants used included sodium carbonate, sodium silicate and quebracho. The choice of these modifying agents, specifically depressants, was determined by the presence of specific gangue minerals. The function of sodium carbonate was chiefly for pH and water hardness control. Sodium carbonate was also used to depress calcite by the formation of surface carbonation. Sodium silicate was used for slime dispersion, and also to depress quartz and calcite. The depression of quartz by sodium silicate is considered to be due to the formation of silicic acid gel on the quartz surface. Quebracho was used to depress calcite.

A summary of collector and modifier concentration data for magnesite flotation is reported in Table 12. Flotation successfully concentrated most magnesite ores to at least 93% grade.

Alternative Beneficiation Methods

The concentration of magnesite by heavy media separation and by wet and dry gravity concentration methods is based on differences in specific gravity between magnesite and gangue minerals. In one study of magnesite from Kilmar, Quebec (65), heavy media separation was used to separate magnesite (S.G. 3.00) from dolomite (S.G. 2.85) and serpentine (S.G. 2.55). The size of ore treated was minus 40 plus 6.7 mm. The weight recovery of one test run was only fair at 60.0% and the product analysis, although registering only 3% insol, also registered 12% CaO (65). The reason for the poor performance is probably due to the narrow differences between the various specific gravities.

The separation of magnesite from brucite (S.G. 2.39) was attempted by air tabling and wet tabling of plus 420 μm material. In each case a 90% magnesite grade was achieved from 65% magnesite feed material (62).

Photometric sorting, utilizing differences in colour and shading, was studied using magnesite from Kilmar, Quebec (68). A degree of concentration was obtained, but the serpentine was not entirely separated.

Magnetic separation as a secondary beneficiation technique to remove iron oxide and iron-containing minerals was employed in a number of studies. Magnetic separation was successful in removing liberated magnetic material from concentrated magnesite flotation concentrates, but it was less successful in removing iron locked in the magnesite crystal lattice (72,73).

Table 12. Summary of Flotation Data for Magnesite Rougher Flotation

Deposit Location	Lot No.	Collectors		Modifiers			Physical Parameters		Reference No.
		Type	Conc. g/t	Type	Conc. g/t	Type	pH	No. of Cleaner Stages	
Newfoundland									
n.s.	1	Neo Fat 142	650	Na ₂ SiO ₃	700		9.1	2	61
Quebec									
Kilmar	1	Oleic Acid	590	Na ₂ CO ₃	1275	Quebracho	n.s.	1	63
			400	Na ₂ CO ₃	950	Quebracho	n.s.	1	
	2	Oleic Acid	520	Na ₂ CO ₃	1525	Quebracho	n.s.	1	
	3	Oleic Acid	330	Na ₂ CO ₃	900	Quebracho	n.s.	1	
Kilmar	1	Oleic Acid	600	Na ₂ CO ₃	600	Quebracho	10.0	1	66
	2	Oleic Acid	850	Na ₂ CO ₃	850	Quebracho	9.7	1	
	3	Oleic Acid	900	Na ₂ CO ₃	1000	Quebracho	10.2	1	
	4	Oleic Acid	850	Na ₂ CO ₃	150	Quebracho	10.1	2	
	5	Oleic Acid	900	Na ₂ CO ₃	400	Quebracho	9.4	1	
British Columbia									
Cranbrook	1	Sodium Oleate	200	-	-		n.s.	1	79
		Oleic Acid	100	-	-				
Cranbrook	1	Neo Fat 142	920	Na ₂ SiO ₃	2000		n.s.	-	80
Fort Steele	1	Harfat	920	-	-		10.1	2	81
	2	Harfat	920	-	-		10.3	9	

n.s. - not specified

Refractory Evaluation

The basic procedure for refractory evaluation involved calcining, hydration, high-pressure briquetting and dead burning to produce a high-density refractory MgO. The physical parameters for refractory evaluation are adequately described by Palfreyman (29) and Svikis (76).

Beneficiation of Brucite

The processing of brucite is very similar to magnesite, that is, beneficiation to produce a brucite concentrate followed by calcination for refractory use evaluation. Beneficiation techniques included screening, flotation and photometric sorting.

Flotation

Flotation was successful in concentrating a low-grade brucite ore from Farm Point, Ontario (90). A brucite concentrate analyzing 88.2% MgO after calcination, and containing very little calcite, was obtained from 31% brucite head material. The grind size was minus 300 μm , and desliming at 60 μm was necessary before flotation. The brucite was floated using a higher aliphatic secondary alcohol sulphate. A fatty acid derivative, potassium stearate, was used in one study with only limited success (92).

Collector concentration data was not reported but high concentration levels would be expected, since alcohol sulphate and stearate collectors are prone to precipitation by dissolved Ca^{2+} and Mg^{2+} . Modifiers included sodium silicate as a slime dispersant and quartz depressant, and tannic acid as calcite depressant.

Alternative Beneficiation Methods

Photometric sorting was employed to remove serpentine and dark-coloured silicate minerals in a study of brucite ore from Wakefield, Quebec (89), with only limited success. It is surprising that heavy media separation was not attempted in any of the studies to separate brucite (S.G. 2.39) from other carbonaceous minerals (calcite, S.G. 2.71; magnesite, S.G. 3.00; and dolomite, S.G. 2.85).

In another study of brucite ore from Wakefield, Quebec (88), sized brucite was successfully evaluated as a source of coarse aggregate for use in concrete.

Refractory Evaluation

The calcination test procedure for brucite differed from magnesite in that after calcination the dried hydrate from brucite was washed and scrubbed in hot water to remove lime (10).

Beneficiation of Dolomite

Dolomite beneficiation was more straightforward than that of magnesite and brucite, because only dry processing was involved. Techniques such as screening, air classification and photometric sorting were studied. Calcination evaluation was different from both magnesite and brucite calcination, in that dolomite was evaluated for either dolomitic lime or as refractory raw material.

Alternative Beneficiation Methods

Air classification of a sample of dolomitic ore from Haley, Ontario, successfully separated a minus 75 μm fraction (99). Photometric sorting of another sample from Haley successfully produced a very white product in the minus 12.5 plus 9.5 mm fraction, and in the minus 9.5 plus 4.8 mm fraction (100).

Refractory Evaluation

Calcination for the suitability of producing dolomitic lime was conducted on a dolomitic ore from Nassagaweya, Ontario. Following calcination, the calcine was pulverized to minus 44 μm and tested for slaking ability. A high slaking reaction was obtained for a calcine analyzing 1.56% LOI (97).

Evaluation of dolomite as a raw material for the production of dolomite refractories differs from refractory evaluation of magnesite and brucite. The dolomite has to be stabilized by pelletizing with the non-magnetic fraction of a sample of serpentine. A sample of dolomitic ore from Haley, Ontario, was successfully evaluated as a refractory raw material by this method. In addition, the dolomitic ore was successfully evaluated as a furnace-fettling compound using iron oxide as the fluxing agent (101).

CONCLUDING COMMENT

This report is the ninth in a Summary Report series on industrial minerals. These reports are designed to assist individuals or companies having interest in industrial minerals in Canada. A wide distribution of the Summary Report series is planned as a means of encouraging interest in the further development of industrial minerals for use in many diverse applications. These applications range from fillers for everyday products such as paint and rubber, to the high-technology sector for products such as high-performance plastics.

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APPENDIX 1

SUMMARIES OF CANMET MAGNESITE STUDIES



NEWFOUNDLAND

Identification : Nfld.-1 (Ref. No. 61)

Report - Title : THE FLOTATION OF A MAGNESITE ORE FROM
NEWFOUNDLAND

- Author : H.L. Beer

- No. and Date : *Ore Dressing Investigation Report* (unnumbered) (1954)

Sample Description : A sample of fine-grained magnesite and quartz with part
of the quartz occurring as large crystalline veinlets.

Objective : To produce high-grade magnesite.

Processing : Dry grinding to minus 210 μm , followed by desliming and
flotation; flotation involved regrinding the rougher
concentrate before cleaning.

Results : A magnesite concentrate analyzing 80.2% MgCO_3 and
10.0% insol, with a weight recovery of 33.3%, was
produced.

Remarks : The quartz content of the magnesite concentrate was too
high because the quartz was very finely intergrown with
the magnesite.

Potential Use : Not suitable for refractory purposes.

QUEBEC

Identification : Que.-1 (Ref. No. 62)

Report - Title : TABLING OF MAGNESITE-RICH BRUCITE MILL PRODUCTS

- Author : R.A. Wyman

- No. and Date : *Investigation Report 58-164 (1958)*

Sample Description : Two samples of magnesite-rich brucite mill products: sample A analyzing 80% magnesite, and sample B 65% magnesite.

Objective : To concentrate each sample to 90% magnesite.

Processing : Air tabling of sample A 'as is' and of the plus 420 and minus 420 μm fractions of sample B. Wet tabling was also conducted on the plus 420 and minus 420 μm fractions of sample B.

Results : Sample A and the plus 420 μm fraction of sample B were concentrated by air tabling to 90% magnesite. Wet tabling of the plus 420 μm fraction of sample B also produced a 90% grade.

Potential Use : Not determined.

Identification	: Que-2 (Ref. No. 63)
Report - Title	: INVESTIGATION ON THE CONCENTRATION OF MAGNESITE ROCK FROM KILMAR
- Author	: J.F. Kostash
- No. and Date	: <i>Ore Dressing Investigation Report</i> 983 (1941)
Sample Description	: Lot No. 1 consisted of 13.5t of 'Magnifrit' and 13.5t of 'Basifrit' crude rock obtained from respective rock piles. The average mineralogical composition was 36.5% dolomite, 51.0% magnesite and 10% serpentine. Lot No. 2 weighed 38.3 t of crude ore and was obtained from underground workings. The average mineralogical analysis was 35% dolomite, 57% magnesite and 6% serpentine. Lot No. 3 weighed 30 t of crude ore and was obtained from a stockpile. The average mineralogical analysis was 43% dolomite, 46% magnesite and 9% serpentine.
Objective	: To obtain high-grade, low-lime magnesite concentrates, and to provide pilot-plant data to aid in a full scale milling process.
Processing	: Crushing to minus 12.5 mm followed by ball mill grinding to minus 400 μ m. The ball mill discharge was hydrosized at 44 μ m to produce a deslimed flotation feed. Magnesite was floated by a rougher, followed by three stages of cleaning configuration, using 25°C warm water. The various middlings were dewatered and reground before retreatment.
Results	: Magnesite recoveries from the treatment of all three lots was between 50 and 60%. The lime content of concentrates produced from Lots 1 and 2 varied from 1.26 to 3.77 % CaO. The lowest lime content obtained from the treatment of Lot 3 material was 2.80% CaO.
Remarks	: The relatively low recoveries were possibly due to the necessity of fine grinding for liberation of magnesite, which produced excessive slimes detrimental to flotation performance. A more efficient desliming, prior to flotation, should overcome this drawback.
Potential Use	: Not applicable.

Identification	: Que.-3 (Ref. No. 64)
Report - Title	: SINK-AND-FLOAT TESTS ON A SAMPLE OF MAGNESITE FROM A CULL DUMP AT KILMAR
- Author	: J.D. Johnson
- No. and Date	: <i>Ore Dressing Investigation Report</i> 1081 (1941)
Sample Description	: A 91 kg sample of low-grade serpentized magnesite analyzing about 35% magnesite.
Objective	: To increase the magnesite grade by rejecting serpentine.
Processing	: Sizing to produce a minus 25 plus 6.7 mm fraction, which was subjected to heavy media separation to remove serpentine. A specific gravity of 2.80 was maintained using finely ground galena.
Results	: A sink product was obtained analyzing 51.2% magnesite with a recovery of 53.5%, based on original feed.
Potential Use	: Suitable to be mixed with higher grade material.

A-63

Identification	: Que.-4 (Ref. No. 65)
Report - Title	: SINK-AND-FLOAT TESTS ON SAMPLES OF MAGNESITE ORE FROM KILMAR
- Author	: J.D. Johnson
- No. and Date	: <i>Ore Dressing Investigation Report 1202 (1942)</i>
Sample Description	: Two lots, each weighing 8 t: Lot-A was a low-grade sample from a surface dump, predominantly dolomite with magnesite and serpentine; Lot-B was a low-grade siliceous sample predominantly magnesite with dolomite and serpentine.
Objective	: To reject a high-lime, high-silica fraction of the ore at a coarse size.
Processing	: Crushing to 40 mm, followed by screening to separate the minus 6.7 mm fines. Each sample was fed through a pilot-plant scale sink-float unit at the rate of 60 kg/h.
Results	: The processing of Lot 1, at a specific gravity of 2.80, produced a sink product analyzing about 3% insol and 12% CaO with a weight recovery between 36 and 45%. The processing of Lot 2, at a specific gravity of 2.83, yielded a product analyzing 12% CaO and 3% insol with a weight recovery of 60%.
Potential Use	: Not determined.

- Identification : Que.-5 (Ref. No. 66)
- Report - Title : FLOTATION CONCENTRATION TESTS ON
DOLOMITIC MAGNESITE ORES FROM KILMAR
- Author : H.L. Beer
- No. and Date : *Ore Dressing Investigation Report 2376 (1948)*
- Sample Description : A 552 kg sample made up of five lots; the analyses are summarized as follows:

	SiO ₂	CaO	MgO	Fe ₂ O ₃
No 1- Run of Mine	3.1	10.7	40.1	0.68
No 2- High Silica	10.3	12.1	43.9	1.20
No 3- High Calcium	1.3	22.6	28.6	0.52
No 4- Harrington	2.9	5.8	42.9	0.34
No 5- North Ore Zone	0.8	10.7	38.2	0.36

- Objective : To produce magnesite concentrates from each lot analyzing <3.5% SiO₂, and <10% CaO.
- Processing : Each lot sample was separately crushed and wet ground to pass 65% minus 75 μ m, followed by desliming at 44 μ m prior to flotation.
- Results : The analyses and recoveries of the best magnesite flotation concentrates obtained from each lot are summarized as follows:

	SiO ₂	CaO	MgO	Recovery
No 1- Run of Mine	0.05	5.4	43.2	77.0
No 2- High Silica	1.26	8.3	40.1	47.8
No 3- High Calcium	0.55	3.9	41.0*	45.2
No 4- Harrington	0.24	0.66	47.1	100.0*
No 5- North Ore Zone	nil	3.7	45.7	76.5

* calculated

- Potential Use : The 'Harrington' and 'North Ore Zone' magnesite concentrates could possibly be suitable for refractory use.

Identification	:	Que.-6 (Ref. 67)
Report - Title	:	DEWATERING TESTS ON MINUS 300 MICRON MAGNESITE FROM THE HEAVY MEDIA SEPARATION PLANT AT KILMAR
- Author	:	R.A. Elliott
- No. and Date	:	<i>Mineral Dressing Investigation Report</i> MD2851 (1951)
Sample Description	:	A 365 kg sample of minus 300 μ m screen undersize analyzing 31.3% MgO, 14.5% CaO and 11.1% SiO ₂ .
Objective	:	To produce a dewatered product for further refractory evaluation.
Processing	:	On-site dewatering tests were conducted with a 75 mm diameter DSM cyclone. Further dewatering of the cyclone underflow was conducted using a rake classifier and a Dorrco filter.
Results	:	The plant screen undersize product was dewatered from 10 to 74% solids, with a solids recovery of 80%. It was recommended that further dewatering of the cyclone underflow should be evaluated using a horizontal belt filter.
Potential Use	:	Not applicable.

A-66

Identification	: Que.-7 (Ref. No. 68)
Report - Title	: PHOTOMETRIC SORTING TRIALS ON MAGNESITE FROM CANADIAN REFRACTORIES LIMITED, KILMAR
- Author	: R.A. Wyman
- No. and Date	: <i>Mineral Processing Test Report 73-5</i> (1973)
Sample Description	: A sample of heavy media plant feed of size analysis from 50 mm to <6.7 mm. The sample contained magnesite and green serpentine.
Objective	: To separate the sample into four distinct types: light grey, medium to dark grey, dark grey to black, and green.
Processing	: The sample was first sized at 25 mm, 19 mm, 13 mm, 10 mm, 6.7 mm and minus 6.7 mm. Each fraction was then subjected to photometric sorting.
Results	: The material representing various shades of light grey and dark grey were successfully separated, but the medium grey and green shades were not separated. The best results were obtained in the 25 to 50 mm size range.
Potential Use	: Not applicable.

Identification	: Que.-8 (Ref. No. 69)
Report - Title	: PRELIMINARY EVALUATION OF THE SEPARATION OF MAGNESITE FROM DOLOMITE IN THE GRENVILLE MAGNESITES
- Authors	: W.B. Timm and R.K. Carnochan
- No. and Date	: <i>Ore Dressing Investigation Report</i> 130 (1920)
Sample Description	: A sample of magnesite and dolomite, predominantly magnesite, analyzing 12.85% CaO, and 34.94% MgO.
Objective	: To separate the dolomite from magnesite.
Processing	: Calcining between 950 and 1100°C followed by slaking of the calcine, and then classification and washing to separate the lime from the calcined magnesite.
Results	: Preliminary results indicated that the CaO content of the calcined magnesite could be reduced to 9% CaO. Further work to optimize the calcination process was recommended.
Potential Use	: Not applicable.

Identification	: Que.-9 (Ref. No. 70)
Report - Title	: THE SEPARATION OF DOLOMITE FROM MAGNESITE IN THE GRENVILLE MAGNESITES
- Author	: R.K. Carnochan
- No. and Date	: <i>Ore Dressing Investigation Report</i> 177 (1922)
Sample Description	: Three samples of magnesite-dolomite ore analyzing: Lot No. 1 23.95% CaO Lot No. 2 12.85% CaO and 24.94% MgO Lot No. 3 11.35% CaO and 35.84% MgO
Objective	: To reduce the CaO content of the calcined magnesite to <3% CaO.
Processing	: A more detailed and extensive optimization of the previous study. Calination was conducted using electric, gas and oil-fired furnaces. Slaking was evaluated by sprinkling the calcined magnesite, with water, when hot and cold; with steam, and with boiling water. Washing was evaluated by agitation and decantation, stirring and washing, tabling and classifying.
Results	: The lowest lime content of the calcined magnesite was 7.1% CaO.
Potential Use	: Unsuitable for refractory applications.

A-69

Identification : Que.-10 (Ref. No. 71)

Report - Title : GRINDING TRIALS ON CALCINED MAGNESITE
FROM CANADIAN REFRACTORIES LIMITED,
GRENVILLE

- Author : R.A. Wyman

- No. and Date : *Mineral Processing Test Report 74-1 (1974)*

Sample Description : A sample of dead-burned magnesite of size analysis 98%
minus 210 μm .

Objective : To produce a product of size analysis 97% minus 20 μm ,
and 60% minus 10 μm .

Processing : Grinding trials were conducted using a laboratory vibrating
Megapact mill with 6.7 mm tungsten carbide balls. Each
of the two grinding chambers were loaded with grinding
balls and two tests were conducted — at 3.5 kg/h for
10 min, and 2.2 kg/h for 15 min.

Results : The 10 min grind resulted in a product that was 74%
minus 22 μm , and 55% minus 11 μm . The 15 min grind
resulted in a product that was 80% minus 22 μm , and
63% minus 11 μm .

Remarks : Vibration milling can produce very fine material in a short
period.

Potential Use : Not applicable.

ONTARIO

Identification	: Ont.-1 (Ref. No. 72)
Report - Title	: CONCENTRATION OF MAGNESITE FROM DELORO TOWNSHIP: PROGRESS REPORT NO. 1
- Author	: F.H. Hartman
- No. and Date	: <i>Internal Report</i> 63-61 (1963)
Sample Description	: A 750 kg sample of minus 250 mm talc-magnesite ore. The mineralogical composition was 57% magnesite, 23% talc, 15% quartz, with minor iron oxide minerals.
Objective	: To produce a high-grade magnesite concentrate.
Processing	: Crushing to 4.8 mm for the separation of a head sample; further crushing to 600 μ m was followed by dry grinding in a ceramic-plate pulverizer to 150 μ m. Flotation involved removal of a talc concentrate, followed by regrinding the unfloated material to 89.5% minus 100 μ m. The silicates were then floated and the enriched magnesite 'flotation tails' product passed through a Jones wet high-intensity magnetic separator to remove iron oxides.
Results	: A magnesite concentrate analyzing 99.38% MgCO_3 and 2.94% Fe_2O_3 , with a recovery of 63.4% was obtained.
Remarks	: A lower iron content concentrate could be obtained by colour sorting the feed prior to the flotation circuit at a size of minus 4.8 + 2.4 mm.
Potential Use	: Not determined.

A-71

Identification : Ont.-2 (Ref. No. 73)

Report - Title : CONCENTRATION OF MAGNESITE FROM DELORO TOWNSHIP: PROGRESS REPORT NO. 2: PILOT PLANT OPERATIONS

- Authors : F.H. Hartman and R.A. Wyman

- No. and Date : *Investigation Report* 64-90 (1964)

Sample Description : A 4 t sample of minus 100 mm talc-magnesite ore. The mineralogical composition was 57% magnesite, 23% talc, 15% quartz, with minor iron oxide minerals.

Objective : To produce a high-grade magnesite concentrate.

Processing : Crushing to 600 μm , followed by autogenous grinding to 210 μm . Flotation was based on previous bench-scale testwork involving flotation of talc, followed by grinding the unfloated material to 75 μm . The silica and iron oxide minerals were then floated, and the upgraded magnesite 'flotation tails' concentrate passed through a Jones wet high-intensity magnetic separator to remove iron oxides. The non-magnetic fraction was screened at 75 μm to remove any coarse impurities.

Results : A 63 kg sample of magnesite concentrate analyzing 99.2% MgCO_3 , 2.96% Fe_2O_3 , 0.56% SiO_2 and 0.038% CaO was prepared for product evaluation.

Potential Use : Not reported.

Identification	: Ont.-3 (Ref. No. 74)
Report - Title	: CONCENTRATION OF MAGNESITE FROM DELORO TOWNSHIP: PROGRESS REPORT NO. 3
- Author	: F.H. Hartman
- No. and Date	: <i>Investigation Report</i> 64-104 (1964)
Sample Description	: A sample of talc-magnesite ore analyzing 57% magnesite, 23% talc, 15% quartz, with minor iron oxide minerals.
Objective	: Evaluation of silica flotation collectors other than Armac T.
Processing	: Bench scale flotation evaluation and ultraflotation (carrier flotation).
Results	: Comparable results to Armac T were obtained using a combination of Ethomeen 18/60 and Duomac T. Ultraflotation, as tested, did not demonstrate any improvement over convential flotation in improving grade and recovery.
Potential Use	: Not applicable.

A-73

Identification	: Ont.-4 (Ref. No. 75)
Report - Title	: CONCENTRATION OF MAGNESITE FROM THE TIMMINS AREA
- Author	: F.H. Hartman
- No. and Date	: <i>Investigation Report</i> 65-4 (1965)
Sample Description	: A 100 kg sample of minus 150 mm lumps of a talc-magnesite ore with minor amounts of chlorite, mica and specularite. Mineralogical analysis indicated 48% talc, 38% magnesite, 12% hematite and 2% quartz.
Objective	: To produce a high-grade magnesite concentrate.
Processing	: Crushing to 4.8 mm for the separation of a head sample; further crushing to 600 μm was followed by dry grinding in a ceramic-plate pulverizer to 150 μm . Flotation involved removal of a talc concentrate, followed by regrounding the unfloated material to 84% minus 44 μm . The silicates were then floated and the enriched magnesite 'flotation tails' product passed through a Jones wet high-intensity magnetic separator to remove iron oxides.
Results	: A magnesite concentrate analysing 99.06% MgCO_3 was obtained, but with a very low recovery; the iron oxide analysis was high at 6.37%.
Potential Use	: Not determined.

- Identification : Ont.-5 (Ref. No. 76)
- Report - Title : DEAD-BURNED MAGNESIA FROM AN ONTARIO
MAGNESITE CONCENTRATE
- Author : V.D. Svikis
- No. and Date : *Bulletin of the American Ceramic Society*, Vol. 48, No. 7,
pp. 724-728 (1969)
- Sample Description : A sample of pilot plant magnesite concentrate prepared
from magnesite occurring at Deloro Township, analyzing
45.10% MgO, 0.50% SiO₂ and 2.80% Fe₂O₃.
- Objective : To produce a dead-burned magnesia suitable for refractory
use.
- Processing : Magnesite concentrate was dry milled to achieve a mean
particle size from 5.7 to 1.5 μ m. Magnesite 'as received'
and the ground batches were mixed with 3% water and
formed into solid cylinder compacts 40 mm diameter and
7 mm thick by compressing at 200,000 kPa. Single-stage
firing of the compacted material was conducted in a
laboratory gas-fired furnace at temperatures between 1650
and 1750°C. Magnesia was also prepared by a two-stage
firing process which involved calcining magnesite 'as
received' at temperatures between 600 and 1200°C. The
cooled calcines were then dry milled to an average particle
size of 1.5 μ m. The ground material was compacted at
200,000 kPa and fired at 1650 and 1750°C.
- Results : Single-stage firing produced a dense 92% magnesia with a
specific gravity of 3.48. The high linear firing shrinkage
of 33%, however, indicated that single-stage firing was
not suitable. Two-stage firing appeared to be more
suitable for producing high quality, dead-burned magnesia
with a specific gravity of 3.47. The linear firing
shrinkage did not exceed 10.8%. The hydration resistance
of sintered grains was improved by combined additions of
0.5 - 1.0% SiO₂ and 0.2% B₂O₃.
- Potential Use : Suitable for refractory applications.

MANITOBA

Identification	: Man.-1 (Ref. No. 77)
Report - Title	: CONCENTRATION OF TALC-MAGNESITE ORES FROM CRANBERRY PORTAGE
- Author	: H.L. Beer
- No. and Date	: <i>Ore Dressing Investigation Report</i> (unnumbered) (1951)
Sample Description	: A 3 kg sample of talc-magnesite ore analyzing 43% talc, 52% magnesite and 5% iron oxide.
Objective	: To produce separate talc and magnesite concentrates.
Processing	: Crushing to 210 μ m, followed by desliming and flotation of talc. The flotation tailings were dried and iron oxide minerals were removed by dry magnetic separation.
Results	: A talc concentrate was obtained analyzing 0.43% Fe_2O_3 and 6.76% LOI with a recovery of about 90%. The magnesite concentrate analyzed 4.38% Fe_2O_3 and 40.89% MgO and represented a recovery of 86.1%.
Potential Use	: The iron oxide levels of both the talc and magnesite concentrates were too high for most high-value applications.

Identification:

Man.-2 (Ref. No. 78)

Report - Title

: FURTHER CONCENTRATION OF TALC-MAGNESITE
ORES FROM CRANBERRY PORTAGE

- Author

: H.L. Beer

- No. and Date

: *Ore Dressing Investigation Report* (unnumbered) (1952)

Sample Description

: Two lots, A and B: lot A weighed 60 kg and analyzed 59% ferro-dolomite and breunnerite, 39% talc and 2% magnetite; lot B weighed 55 kg and analyzed 44% ferro-dolomite and breunnerite, 52% talc and 4% magnetite.

Objective

: To produce separate talc and magnesite concentrates.

Processing

: Grinding to 210 μm , followed by talc flotation and magnesite flotation.

Results

: A talc concentrate was produced from lot A material analyzing 2.8% Fe_2O_3 and 17.6% LOI, with a weight recovery of 56.9%. The talc concentrate produced from lot B material analyzed 2.9% Fe_2O_3 and 18.4% LOI, and represented a weight recovery of 57.9%.

Very little magnesite was recovered, since the carbonaceous fraction of each lot was mainly ferro-dolomite.

Potential Use

: The iron oxide content of the talc concentrate was too high for high-value applications.

BRITISH COLUMBIA

- Identification : B.C.-1 (Ref. No. 79)
- Report - Title : THE CONCENTRATION BY FLOTATION OF
MAGNESITE FROM MARYSVILLE, NEAR
CRANBROOK
- Author : R.K. Carnochan
- No. and Date : *Ore Dressing Investigation Report* (unnumbered) (1935)
- Sample Description : A 34 kg sample of magnesitic ore analyzing 40.66%
MgO, 10.72% insol, and 2.36% Al_2O_3 and Fe_2O_3 .
- Objective : To produce high-grade magnesite.
- Processing : Crushing to pass 840 μm , followed by grinding to about
minus 75 μm . Flotation involved the production of two
separate rougher concentrates, which were mixed and
cleaned once.
- Results : A magnesite concentrate analyzing 92.8% $MgCO_3$ with a
recovery of 91.14% was produced.
- Potential Use : Not determined, although the magnesite concentrate was
very high grade.

A-78

Identification	: B.C.-2 (Ref. No. 80)
Report - Title	: BENEFICIATION OF MAGNESITE-BEARING ROCK FROM CRANBROOK, SOUTH-EAST BRITISH COLUMBIA
- Author	: W.J.D. Stone
- No. and Date	: <i>Industrial Minerals Test Report</i> 58-107 (1958)
Sample Description	: A sample of magnesite ore analyzing 91.4% magnesite, 5.3% chlorite and 3.6% quartz.
Objective	: To produce high-grade magnesite with excellent firing properties.
Processing	: Rolls crushing to minus 600 μm , dry grinding to minus 150 μm in a pebble mill, followed by flotation. A calcination test was conducted on the head sample and compared to a known standard. Firing tests were conducted on the head sample, and a high-grade magnesite flotation concentrate.
Results	: Flotation produced a magnesite concentrate analyzing 96.1% MgCO_3 with a recovery of 86.4%. The calcined head sample analyzed 83.6% MgO, 2.3% Al_2O_3, 3.6% Fe_2O_3, 10.2% SiO_2 and 0.3% CaO. The firing tests were conducted at 1650°C on ground material that had been pressed to 2109 t/m². The sinter for both head sample and concentrate were very tough dense products.
Potential Use	: Possibly suitable for commercial applications of dead-burned, high-density MgO .

Identification	: B.C.-3 (Ref. No. 81)
Report - Title	: CONCENTRATION OF MAGNESITE FROM FORT STEELE
- Authors	: W.J.D. Stone and R.A. Wyman
- No. and Date	: <i>Investigation Report</i> 60-9 (1960)
Sample Description	: Two samples of magnesite ore, each weighing 3 t, and designated 'high grade' and 'low grade'. The high-grade sample analyzed 87% magnesite, 5% chlorite, 6% talc, 1% quartz and 1% iron oxide. The low-grade sample analyzed 47% magnesite, 32% chlorite, 1% talc, 18% quartz and 2% iron oxide.
Objective	: To produce high-grade magnesite with excellent firing characteristics.
Processing	: Crushing of both samples by jaw and cone crushing, followed by pebble milling to minus 420 μm . A number of laboratory flotation tests were conducted on low-grade, intermediate-grade, and high-grade material, so as to optimize parameters for subsequent pilot-plant testwork. Pilot plant evaluation was conducted on minus 300 μm material with five stages of cleaning. Calcination tests were performed on various flotation concentrates.
Results	: Flotation concentrates grading 95% magnesite with 90% or better recovery were obtained from high-grade or intermediate-grade magnesite feeds. The best result, with low-grade feed, was a concentrate analyzing 92% magnesite at 80% or better recovery. Calcined magnesite with an MgO content of 90% and a specific gravity of 3.0 was produced from magnesite concentrates grading from 47 to 87% magnesite.
Potential Use	: Possibly suitable for commercial applications of dead-burned magnesite.

- Identification : B.C.-4 (Ref. No. 82)
- Report - Title : EVALUATION OF A SAMPLE OF A BRITISH COLUMBIA MAGNESITE AS A REFRACTORY RAW MATERIAL
- Author : M. Palfreyman
- No. and Date : *Investigation Report 71-17 (1971)*
- Sample Description : A 4.5 kg sample of high-grade magnesite.
- Objective : To produce dead-burned magnesia suitable for refractory purposes.
- Processing : Single-stage processing involved grinding to $< 1 \mu\text{m}$ using fused alumina, pressing at 17.6 kg/mm^2 with 3% water, and drying overnight at 80°C . Firing was conducted at 1650°C and 1700°C with no soaking period, and at 1700°C with 1 hr and 3 hr soaking periods. Fired bulk densities and apparent porosities were determined.
- Two-stage processing involved prior calcining in an electric furnace for 3 hr at 900°C , 2 hr at 1000°C , and 2 hr at 1100°C . Subsequent evaluation was similar to the single-stage processing procedure.
- Results : Single-stage processed fired-bulk density was 3.37 g/mL . The fired density was not affected by soaking periods up to 3 hr. Two-stage processing demonstrated that fired densities increased with calcining temperature. Densities varied from 3.41 g/mL for material calcined at 900°C , to 3.48 g/mL for a calcining temperature of 1100°C .
- Potential Use : Satisfactory as a raw material for the production of refractory-grade, dead-burned magnesia.

Identification : B.C.-5 (Ref. No. 83)

Report - Title : PRODUCTION OF DEAD-BURNED MAGNESIA
FROM MAGNESITE OBTAINED FROM THE
BAYMAG PROPERTY, BRUSILOF MOUNTAIN

- Author : M. Palfreyman

- No. and Date : *Unpublished Report*, 1973

Sample Description : A composite flotation concentrate analyzing 98.6% MgO,
0.49% Fe₂O₃, 1.16% CaO and 0.12% SiO₂.

Objective : To produce a high-density, dead-burned magnesia product.

Processing : Calcining at 900 to 1100°C, regrinding, drying and
hydrated pressing, and burning at 1600 to 1800°C.

Results : The best results were obtained on material dried at 400°C
prior to briquetting. The best calcining temperature
appeared to be 1100°C, and the best dead-burning
temperature was 1800°C.

Potential Use : Not applicable.



APPENDIX 2

SUMMARIES OF MAGNESITE STUDIES BY OTHER ORGANIZATIONS

NEWFOUNDLAND

Identification	: Nfld.-2 (Ref. No. 84)
Report - Title	: BENEFICIATION OF A BREUNNERITE-MAGNESITE SAMPLE FROM NEWFOUNDLAND
- Author	: T.L.B. Jepsen
- No. and Date	: <i>Report for Basic Refractories Incorporated Nevada, U.S.A., 1971</i>
Sample Description	: A sample of breunnerite-magnesite ore containing a high content of magnetic iron silicate. A major part of the iron appeared as inclusions within the magnesite crystal.
Objective	: To produce a high-grade concentrate suitable for refractory use.
Processing	: Crushing to pass 4.8 mm and sizing at 210 μm . The sized product was subjected to heavy liquid separation to produce a sink product. The sink product was ground to pass 150 μm , deslimed at 15 μm , and subjected to magnetic separation and flotation with three stages of cleaning. The concentrate was ground finer to pass 75 μm , and subjected to heavy liquid separation to reject more silica.
Results	: The flotation concentrate analyzed 73.03% MgO which, after further heavy liquid separation, was upgraded to 76.43% MgO in the sink fraction. The silica content was reduced to 2.89%.
Potential Use	: Not suitable for refractory use.

B-86

Identification	: Ont.-6 (Ref. No. 85)
Report - Title	: THE RECOVERY OF MAGNESITE FROM A TALC MAGNESITE ORE FROM NORTHERN ONTARIO
- Author	: R.J.C. Tait
- No. and Date	: <i>Lakefield Research Report</i> LR 920 (1963)
Sample Description	: A 500 kg trench sample and various drill core samples of a talc-magnesite ore.
Mineralogy	: The trench sample analyzed 29.98% MgO and 6.27% Fe ₂ O ₃ ; the drill core samples analyzed 24.90% MgO and 5.72% Fe ₂ O ₃ . These analyses represent approximately 60% magnesite for the trench sample, and 50% magnesite for the drill cores.
Objective	: To produce a magnesite concentrate analyzing 95% MgO, 1% SiO ₂ and 4% Fe ₂ O ₃ .
Processing	: Crushing to 850 μ m, grinding to 100% minus 210 μ m, flotation and magnetic separation. The flotation processing route for each sample was flotation of talc, followed by flotation of silica leaving an enriched magnesite product as the flotation tailing.
Results	: The optimum result using either sample, was a magnesite concentrate analyzing 93% MgO (DBE)*, 1% SiO ₂ and 6% Fe ₂ O ₃ .
Remarks	: The high iron oxide content of the magnesite concentrate was due to finely divided hematite and, in part, to the substitution of magnesium for iron in the magnesite crystal lattice. High-intensity magnetic separation was partially successful in reducing the iron oxide content, but only to 3% Fe ₂ O ₃ .

* Dead-Burned Equivalent

B-87

- Identification : Ont.-7 (Ref. No. 86)
- Report - Title : PILOT PLANT EVALUATION OF A TALC-MAGNESITE ORE FROM DELORO TOWNSHIP
- Author : Unknown
- No. and Date : *Unnumbered Report for Canadian Magnesite Limited, 1964*
- Sample Description : A 2000 t sample of talc-magnesite ore analyzing 54% magnesite, 28% talc and 16% quartz, with minor iron oxides.
- Objective : To produce a high-grade magnesite concentrate suitable for refractory use.
- Processing : Grinding to 70% minus 75 μ m, followed by flotation to remove talc, and cationic flotation to remove silica in a 2 tph pilot plant.
- Results : A 500 t sample of high-grade magnesite was produced analyzing 99.1% MgCO_3 , 2.85% Fe_2O_3 and 0.5% SiO_2 , with a recovery of 70%.

The carbonate concentrate was calcined to produce a caustic-calcined magnesia. The calcine was further treated by fine grinding, hydration, high pressure briquetting, and dead burning to produce a high density, dead-burned product for refractory use having the following chemical and physical properties:

Chemical Analysis:

Magnesia (MgO)	92.5%
Iron Oxide (Fe_2O_3)	6.0%
Silica (SiO_2)	1.0%
Miscellaneous	0.5%

Physical Properties:

Grain Density	3.4 to 3.45
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The 30% portion of the magnesite lost to tailings in the flotation process can be chemically recovered by dissolving in hydrochloric acid (Ruthner Process), and burning the MgCl_2 product to produce high- purity magnesia (MgO).

- Potential Use : Suitable for commercial grade dead-burned MgO , caustic-calcined MgO and, after treatment by the Ruthner process, high- purity MgO .

Identification	: Ont. 8 (Ref. No. 87)
Report - Title	: PILOT PLANT FLOTATION OF TALC AND MAGNESITE FROM TALC MAGNESITE ORE FROM NORTHERN ONTARIO
- Authors	: R. Craig and C. Cox
- No. and Date	: <i>Colorado School of Mines Report 75-25 (1975)</i>
Sample Description	: A 2 t sample of talc-magnesite ore.
Mineralogy	: Major talc and magnesite with minor quartz, hematite and chlorite.
Objective	: To produce specification-grade magnesite suitable for ceramic uses.
Processing	: Stage crushing to 3.4 mm by jaw and rolls crushers, followed by grinding to minus 150 μm . Flotation produced a talc rougher concentrate, which was then reground to 80% minus 44 μm , followed by five stages of cleaning. A quartz concentrate was then floated leaving an enriched magnesite concentrate in the flotation tails. Iron oxide minerals were removed before flotation by gravity concentration using a shaking table.
Results	: A magnesite concentrate was obtained analyzing 96% MgCO_3 and 0.42% SiO_2 , with a recovery of 71.5%.

APPENDIX 3

SUMMARIES OF CANMET BRUCITE STUDIES

C-91

NOVA SCOTIA

- Identification : N.S.-1 (Ref. No. 10)
- Report - Title : INVESTIGATION OF THE RECOVERY OF
MAGNESIA FROM BRUCITIC LIMESTONE FROM
MEAT COVE
- Author : J.S. Ross
- No. and Date : *Mineral Processing Test Report 62-37 (1962)*
- Sample Description : Several samples of minus 200 mm brucitic limestone; most
were weathered and only one, lot 4, was fresh and very
competent. The colour varied from greenish-grey to grey,
and some pieces were noticeably iron-stained. The
principal minerals were calcite, serpentine and brucite,
with minor iron sulphides and oxides. Lot 4 analyzed
11.9% brucite.
- Objective : To produce high-grade magnesia.
- Processing : Three, 2.5 kg samples were prepared from lot 4, and each
were screened at 6.5 mm to discard undersize material.
Each sample was calcined for 2 hr, hydrated, and allowed
to stand for 30 min. The dried hydrate was washed and
scrubbed in hot water to remove lime, and screened to
remove silicate minerals.
- Results : The recovery of magnesia was too low for economic
consideration.
- Potential Use : Unsuitable as a source of magnesia.

QUEBEC

Identification	: Que.-1 (Ref. No. 88)
Report - Title	: EVALUATION OF BRUCITIC LIMESTONE FROM WAKEFIELD FOR USE AS CONCRETE AGGREGATE
- Author	: N.G. Zoldners
- No. and Date	: <i>Investigation Report 62-57</i> (1962)
Sample Description	: A 270 kg sample of crushed brucitic limestone, up to 20 mm in size, analyzing 70% calcite, 19% brucite, 9% serpentine, with minor dolomite, graphite, and iron sulphides and oxides.
Objective	: To determine suitability for use in concrete aggregate.
Processing	: The sample was sized at 20, 12.5, 9.5 and 4.8 mm. Selected fractions were chosen for the determination of bulk specific gravity, absorption tests, and sulphate soundness loss. Two identical air-entrained concrete test mixes were prepared. The first test mix was prepared with crushed brucitic limestone as coarse and fine aggregate. The second mix was prepared with natural sand using the same type of coarse aggregate. Each concrete specimen was subjected to standard ASTM* test procedures.
Results	: The best results were obtained when the sample of brucitic limestone was incorporated as coarse aggregate, with natural sand as fine aggregate; good strength performance and durability were obtained.
Potential Use	: Suitable for use in concrete aggregate.

* American Society for Testing Materials

C-93

Identification	: Que.-2 (Ref. No. 89)
Report - Title	: PHOTOMETRIC SORTING OF BRUCITIC LIMESTONE FROM WAKEFIELD
- Author	: R.A. Wyman
- No. and Date	: <i>Mineral Processing Test Report</i> 68-1 (1968)
Sample Description	: A 65 kg sample of high-grade brucitic limestone associated with serpentine and other dark-coloured silicate minerals.
Objective	: To produce high-grade brucitic limestone.
Processing	: Sizing into two fractions: minus 12.5 plus 9.5 mm and minus 9.5 plus 4.8 mm. Each fraction was subjected to photometric sorting to reject the dark-coloured silicates.
Results	: The results indicated that only the very dark material was rejected, since a wide range of shading was represented by the various minerals. The grade of the brucitic limestone was not, however, significantly improved.
Potential Use	: Not determined.

C-94

ONTARIO

Identification	: Ont.-1 (Ref. No. 90)
Report - Title	: FLOTATION OF BRUCITIC LIMESTONE FROM FARM POINT
- Author	: R.L. Bennett
- No. and Date	: <i>Ore Dressing Investigation Report</i> (unnumbered) (1941)
Sample Description	: A sample of brucitic limestone analyzing 64% limestone, 31% brucite and 4% magnesite.
Objective	: To produce a high-grade brucite concentrate suitable for refractory use.
Processing	: Crushing to 1.2 mm, followed by grinding to 99% minus 300 μ m in a pebble mill preparatory to flotation. The ground product was deslimed at 60 μ m, and brucite floated from calcite using a higher aliphatic secondary alcohol sulphate.
Results	: A selective brucite concentrate was obtained containing very little calcite. The analysis after calcination was 88.2% MgO, 8.2% CaO, 1.4% R ₂ O ₃ and 2.2% insol.
Potential Use	: Possibly suitable for refractory uses.

APPENDIX 4

SUMMARIES OF BRUCITE STUDIES BY OTHER ORGANIZATIONS

QUEBEC

Identification	: Que.-3 (Ref. No. 91)
Report - Title	: BENEFICIATION OF A SAMPLE OF CALCINED BRUCITE FROM BRYSON, AND A SAMPLE OF CALCINED MAGNESITE FROM KILMAR
- Author	: O. Staples
- No. and Date	: <i>Unpublished Report for Denver Equipment Company Canada Limited</i> (1939)
Sample Description	: A sample of calcined brucite covered with and occasionally cemented by lime, and a sample of calcined magnesite.
Objective	: To reduce the SiO_2 and CaO contents.
Processing	: Water washing by agitation, followed by settling and decantation to remove solubilized lime. The decanted product was beneficiated by reverse flotation to remove lime and siliceous material. Direct flotation of brucite and magnesite was also attempted.
Results	: Satisfactory beneficiation of either calcined material was not obtained.
Potential Use	: Not suitable for refractory purposes.

ONTARIO

Identification	: Ont.-2 (Ref. No. 92)
Report - Title	: BENEFICIATION OF SAMPLES OF BRUCITE ORE FROM RUTHERGLEN
- Author	: O. Staples
- No. and Date	: <i>Unpublished Report for Denver Equipment Company Canada Limited (1939)</i>
Sample Description	: A 125 kg sample of low-grade carbonaceous brucite ore consisting mainly of calcite, dolomite and serpentine, with less than 10% brucite.
Objective	: To produce a high-grade brucite concentrate.
Processing	: Crushing to 1.7 mm, followed by riffing of several lots for flotation. Flotation was conducted, after grinding to an unspecified size, using a variety of collectors and modifiers.
Results	: A brucite concentrate was obtained analyzing 51.3% MgO with a recovery of 74.8%. A selective collector for brucite was not found, since carbonaceous and siliceous material always floated with brucite.
Potential Use	: Too low grade for refractory use.

APPENDIX 5

SUMMARIES OF CANMET DOLOMITE STUDIES



NOVA SCOTIA

Identification	: N.S.-1 (Ref. No. 93)
Report - Title	: CRUSHING TESTS ON A SAMPLE OF DOLOMITE FROM DOMINION STEEL AND COAL CORPORATION, SYDNEY
- Author	: R.K. Carnochan
- No. and Date	: <i>Ore Dressing Investigation Report</i> (unnumbered) (1938)
Sample Description	: A 450 kg sample of coarse dolomite up to minus 300 mm in size.
Objective	: To produce a crushed product of minus 19 mm size, with a minimum production of minus 6.3 mm.
Processing	: Crushing of the dolomite was effected by various methods: a) Stage jaw crushing with screening of the oversize followed by crushing at a finer size. b) Gyratory crushing at 19 mm, followed by horizontal disc crushing to 9.5 mm. The plus 19 mm disc crusher oversize was re-crushed by a rolls crusher. c) Hammer crushing followed by jaw crushing to 22 mm, with rolls crushing of the 19 mm oversize; best results were obtained with the rolls crusher set at 12.5 mm.
Results	: The minimum production of minus 6.3 mm fines was 26.2% and was obtained by a combination of hammer, jaw and rolls crushing.
Potential Use	: Not applicable.

NEW BRUNSWICK

- Identification : N.B.-1 (Ref. No. 94)
- Report - Title : CALCINING TESTS ON DOLOMITE FROM ST. JOHN COUNTY
- Author : J.S. Ross
- No. and Date : *Industrial Minerals Report* 59-30 (1959)
- Sample Description : Three samples totalling 20 kg: sample A was a dark grey, fine-grained, magnesian limestone with minor calcite; sample B was a grey, fine-grained, finely banded dense dolomite, with calcite and minor quartz, and sample C was similar to Sample B, but light grey in appearance.
- Objective : To evaluate as a source of dolomitic limestone.
- Processing : A 75 to 100 mm size rock fragment from each sample was calcined separately in a Remmey gas-fired furnace. The temperature was increased rapidly to 980°C for sample A, 1090°C for sample B, and 1200°C for sample C over a period of 25 to 40 min. The calcination temperature was kept constant for 2 hr. Each sample, after calcination, was cooled to room temperature, pulverized to 44 μ m, tested for slaking ability, and analyzed for LOI.
- Results : The slaking ability of each sample was very high, and the LOI values low, 1.46% for sample A, 0.87% for sample B, and 0.56% for sample C. Numerous open fractures occurred at high slaking temperatures; less fracturing occurred at 980°C.
- Potential Use : Possibly suitable for refractory purposes if a time-temperature relationship can be established which will not result in fracturing.

E-103

QUEBEC

Identification : Que.-1 (Ref. No. 95)

Report - Title : SCREEN TEST ON CRUSHED DOLOMITE FROM
PORTAGE DU FORT

- Author : M.F. Goudge

- No. and Date : *Ore Dressing Investigation Report* (unnumbered) (1945)

Sample Description : A 15 kg sample of crushed dolomite.

Objective : To produce a crushed minus 12.5 plus 4.8 mm product
with minimum fines.

Processing : Jaw crushing to 25 mm followed by rolls crushing to
9.5 mm. The crushed product was screened from
12.5 mm through successive stages to 600 μ m, and the
plus 12.5 mm oversize was re-crushed to pass 9.5 mm.

Results : A recovery of 62.4% of the minus 12.5 plus 4.8 mm
fraction was obtained.

Potential Use : Not applicable.

ONTARIO

Identification	: Ont.-1 (Ref. No. 96)
Report - Title	: EXPERIMENTAL TESTS ON THE POSSIBLE USE OF AN OCCURRENCE OF DOLOMITIC LIMESTONE FOR THE CYANIDE TREATMENT OF HOWEY GOLD ORE FROM RED LAKE
- Authors	: M.F. Goudge and J.S. Godard
- No. and Date	: <i>Ore Dressing Investigation Report</i> 379 (1930)
Sample Description	: Five samples of dolomitic limestone, four low-grade, and one high-grade. The high-grade sample analyzed 36.75% MgCO_3 , 50.84% CaCO_3 and 7.12% insol.
Objective	: To produce a high-grade limestone suitable for use in cyanide leaching of gold ores.
Processing	: The first four samples were burned at 1200°C for 2 hr, and then slaked for 6 hr in water. The fifth sample was burned at 900°C for 2 hr, and slaked in water for 5 min. A sample of the burnt dolomitic limestone obtained from the fifth sample was compared with a standard limestone for available CaO, alkalinity, lime consumption, effect on extraction of gold and cyanide consumption, and settling rate.
Results	: The sample of burnt dolomitic limestone compared favourably to the commercial limestone for each of the parameters tested.
Potential Use	: Suitable for use in the cyanide extraction of gold.

E-105

Identification : Ont.-2 (Ref. No. 97)

Report - Title : BURNING TESTS ON DOLOMITE FROM
NASSAGAWEYA TOWNSHIP

- Author : J.S. Ross

- No. and Date : *Industrial Minerals Report* 59-3 (1959)

Sample Description : A sample of very pure dolomite drill core. The appearance was gray to brownish buff, with a granular sugary texture and moderately to highly porous with vugs up to 25 mm.

Objective : To produce dolomitic lime by calcination.

Processing : Several 40 mm lengths of core were each calcined separately in a Remmey gas-fired furnace at 315°C. The temperature was increased as rapidly as possible to between 980 and 1090°C over 15 to 30 min and kept constant for a period of 2 hr. Each sample when calcined was cooled to room temperature, pulverized to minus 44 μ m, tested for slaking qualities, and analyzed for LOI.

Results : A high slaking reaction was observed for a sample analyzing 1.56% LOI, and a moderate slaking reaction for a sample analyzing 0.95% LOI.

Potential Use : Suitable for the production of dolomitic lime.

Identification : Ont.-3 (Ref. No. 98)

Report - Title : SCREENING TESTS ON DOLOMITE FROM HALEY
- Author : R.A. Wyman
- No. and Date : *Mineral Processing Test Report* 63-17 (1963)

Sample Description : A 90 kg sample of minus 600 μm dolomite containing 22.8% minus 75 μm material.

Objective : To separate the minus 75 μm fraction.

Processing : Screening at 100 μm using a Hammer screen at various feed rates — 146, 420, 650 and 780 kg/h/m².

Results : Excellent separation was obtained at each feed rate indicating a very high capacity for this material. The lowest rejection, 94.5%, was obtained with the highest feed rate.

Potential Use : Not applicable.

E-107

Identification : Ont.-4 (Ref. No. 99)

Report - Title : AIR SEPARATION TESTS ON A THIRD SAMPLE OF
DOLOMITE FROM HALEY

- Author : R.A. Wyman

- No. and Date : *Mineral Processing Test Report* 63-62 (1963)

Sample Description : A 430 kg sample of minus 420 μm dolomite containing
24% minus 75 μm .

Objective : To separate a minus 75 μm fraction.

Processing : Air classification using a Hardinge Gyrator classifier at a
feed rate of 43 kg/h.

Results : A separation was obtained, consisting of a coarse fraction
of 59.6% weight, and a fine fraction of 40.4% weight.
The fine fraction contained 60% minus 75 μm .

Potential Use : Not applicable.

Identification	: Ont.-5 (Ref. No. 100)
Report - Title	: PHOTOMETRIC SORTING OF DOLOMITE FROM HALEY
- Author	: R.A. Wyman
- No. and Date	: <i>Mineral Processing Test Report</i> 66-12 (1966)
Sample Description	: A small sample of high-grade dolomite associated with off-coloured grey silicate minerals.
Objective	: To produce a pure-white product.
Processing	: Sizing into two fractions of minus 12.5 plus 9.5 mm, and minus 9.5 plus 4.8 mm, followed by photometric sorting.
Results	: Two passes through the photometric separator produced a very white product for each fraction. An 80% recovery was possible with the minus 12.5 plus 9.5 mm fraction, and an 86% recovery was possible with the minus 9.5 plus 4.8 mm fraction.
Potential Use	: Suitable as high-grade exposed aggregate.

Identification	: Ont.-6 (Ref. No. 101)
Report - Title	: EVALUATION OF AN ONTARIO DOLOMITE FROM HALEY AS A REFRACTORY RAW MATERIAL
- Author	: M. Palfreyman
- No. and Date	: <i>Investigation Report 74-7</i> (1974)
Sample Description	: A sample of high-grade, near stoichiometric composition dolomite.
Objective	: Evaluation as a raw material for the production of stabilized dolomite refractories, and also for use as a furnace-fettling material.
Processing	: Furnace fettling evaluation was conducted using iron oxide as the fluxing agent. Single-stage processing involved grinding with fused alumina, mixing with various quantities of iron oxide, pelletizing with methyl cellulose, drying overnight, and finally firing at 1600 and 1700°C. Two-stage processing involved prior calcining in an electric furnace for 30 min at 1000°C. Subsequent evaluation was similar to single-stage processing. Dolomite stabilization was conducted by mixing the dolomite with the non-magnetic fraction of a sample of serpentine, pelletizing the mixture, and firing for 1 hr at 1860°C.
Results	: The maximum fired bulk density in the fettling evaluation, 3.2 g/mL, was obtained using 8% by weight iron oxide. Dolomite stabilization was only possible using low-iron serpentine; fired density was 3.2 g/mL.
Potential Use	: Suitable as a furnace-fettling compound and a refractory raw material.